THE ROLE OF SOCIAL, ENVIRONMENTAL, AND HEALTH-RELATED FACTORS ON PHYSICAL ACTIVITY AND FUNCTIONAL HEALTH OUTCOME IN COMMUNITY-DWELLING OLDER ADULTS: A SECONDARY ANALYSIS USING DATA FROM THE NATIONAL SOCIAL LIFE, HEALTH, AND AGING PROJECT (NSHAP).

A Thesis

Presented to the Faculty of the Graduate School

of Cornell University

In Partial Fulfillment of the Requirements for the Degree of Master of Science

by

Adisa Delano Soren

August 2017

ABSTRACT

A secondary analysis was performed using cross-sectional and longitudinal data from a nationally representative, population-based survey study on factors related to older adult health and well-being. The present study includes a subsample of 918 community-dwelling US older adults aged 65-85 (M = 72.6, SD = 5.4) who were functionally independent at baseline assessment. The study sought to examine the relationship between baseline morbidity status and five-year functional health status. In addition, the frequency in which older adults engaged in physical activity was explored as a potential mediator to this relationship. Lastly, physiological, social, and physical environment characteristics were evaluated in relation to physical activity frequency. Results revealed that having more numerous health conditions and less frequent performance of physical activity was related to poorer functional health at five-year follow-up $R^2 = .10$ $F(2, 915) = 51.16$, $p < .001$. In addition, arthritis emerged as a key health condition that significantly predicted five-year functional health status $b = -.29$ $t(914) = -4.02$, $p < .001$. Frequent social contact with family/friends was positively related to physical activity frequency, while body pain intensity was inversely related to physical activity frequency. Neighborhood-level characteristics were not significantly related to physical activity frequency. Future directions are explored.

BIOGRAPHICAL SKETCH

Prior to matriculating at Cornell University, Adisa Soren served as a user experience researcher at Northwestern University, where he collaborated with a multidisciplinary team of research-scientists and technologists to develop mobile and web-based digital health applications with the goal of making healthcare services more accessible and affordable to difficult-to-reach populations. Through his professional experiences, and as a witness to a US healthcare system fraught with inefficiencies, Adisa grew increasingly passionate about leveraging technology to improve the delivery of healthcare services, and working to extend these services beyond traditional healthcare settings to become more fully integrated within community settings. Adisa's goals in transitioning to Cornell University were to strengthen his skills as a Human Factors Engineer/ UX Researcher, and deepen his knowledge of design research methodologies, technological trends, and business strategy. The inspiration for his thesis research, in part, emerged from the recesses of his memory, and reflections on his late grandmother's struggles with maintaining an active lifestyle and social contacts as she grappled with Alzheimer's disease.

Adisa has accepted a role as a user experience researcher at Google where he hopes to continue learning about strategies to leverage technology for positive social impact, with the goal of eventually using his experiences, knowledge, and networks to address issues in the healthcare industry.

ACKNOWLEDGEMENTS

I would like to express my deepest gratitude to all the members of my Special Committee for your encouragement and advisement throughout this journey.

To my chair, Dr. Rana Zadeh, thank you for your dedication and insight. Throughout the course of my graduate career, you have served as my primary source of support, celebrating my successes, and providing me with perspective to see beyond disappointment.

To my minor chair, Dr. Erin York Cornwell, thank you for your responsiveness, flexibility, and steadfast support. You became my saving grace, and by sharing your resources with me, the path ahead became less daunting.

To my additional member, Dr. Gary Evans, thank you for more than you know. Too often, I have found myself wallowing in obscurity, and mesmerized by inchoate ideas. Fortunately, your sage advice has been timely, and has enabled me to regain a sense of clarity in my research.

Lastly, I would like to thank Dr. Elaine Wethington for accommodating this 11th hour request; Françoise Vermeylen for your statistical expertise—you have been an invaluable resource for me; and to Cornell graduate faculty more broadly—your scholarship and commitment to excellence inspired me each time I stepped foot on campus.

Lastly, I would like to thank my graduate student colleagues in DEA—truly an outstanding cohort!

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 Introduction

The present investigation explores the relationships between several factors endemic to older adulthood as contributing to functional health outcomes over a five-year period. Considerations were made for the impact that baseline morbidity status has on functional health outcome, and the role of physical activity in mediating this relationship. In addition, physiological, social and physical environment characteristics were evaluated as potential moderators of the relationship between morbidity status and physical activity frequency. This research is consistent with an aging-in-place paradigm that emphasizes interventions that support older adults in maintaining their independence in the home setting during the latter stages of life. Furthermore, this research is based on theoretical conceptions of functional disability as proposed by Verbrugge and Jette (1994). A secondary analysis was performed using Wave 1 (W1) and Wave 2 (W2) datasets from the National Social Life, Health, and Aging Project (NSHAP), which is a longitudinal, population-based study on indices of older adult health and well-being (O'Muircheartaigh, Eckman, and Smith, 2009).

1.2 Research Objectives

Consistent with global trends on aging, the share of US adults aged 65 and above is undergoing marked growth, with recent projections indicating that older adults will number one-in-five Americans by the year 2030—up from 14.5% (Center for Disease Control, 2013).

Further, for adults aged 80-89, the fastest-growing age cohort, disability rates are the highest of any age group (Rochat, Cumming, Blyth, Creasey, Handelsman, Le Couteur, Naganathan, Sambrook, Seibel, and Waite, 2010; World Health Organization, 2011). This consequential shift in age demographics is propelled by myriad forces, including baby boomers' transition to retirement age, advances in life-extending medical treatments, and general improvements to overall population health (Vincent and Velkoff, 2010). As of 2013, national health expenditures had risen to $2.9 trillion, constituting 17% of Gross Domestic Product (GDP), and 36% of all healthcare spending was generated by older adults (Center for Medicare and Medicaid Services, 2010; Center for Disease Control, 2013).

Successful aging, or physical, mental, and social well-being in older adulthood (Rowe and Kahn, 1997), is compromised by age-related changes to body structures, which engender a high prevalence of disease, disability and loss of independence (Sattelmair, Pertman, and Forman, 2009). Non-communicable diseases (e.g., coronary heart disease, diabetes mellitus) that are common in older adulthood have been shown to increase disability risk (Hallal, Andersen, Bull, Guthold, Haskell, and Ekelund, 2012). Thus, older adults make up a disproportionate share of disabled persons, exceeding 35% of all US cases (WHO, 2011). If prevailing trends persist, national health expenditures are projected to rise to nearly 34% of GDP by 2030 (WHO, 2011). In response to this phenomenon, researchers have emphasized health promotion at the neighborhood level, and designing communities that both accommodate the limitations of older adults and are responsive to their health-related needs (Cubbin, Egerter, Braveman, Pedregon, 2008).

By advancing the body of literature that describes the causes and consequences of disability in older adulthood, public policy may be developed that effectively responds to the health-related challenges facing an aging population. Roughly nine-in-ten older adults have expressed a preference for aging-in-place, and many intend on remaining in their homes indefinitely (Wahl, Iwarsson, and Oswald, 2012). Older adults report that personal home environments address intrinsic needs such as belongingness, familiarity, autonomy, security, and personal identity, and thereby enhance their quality of life (Wiles, Leibing, Guberman, Reeve, and Allen, 2011; Wahl, Iwarsson, and Oswald, 2012). Furthermore, economic costs associated with keeping older adults in their homes are significantly lower than costs associated with transitioning older adults to residential care facilities, with community-dwelling older adults also reporting a higher quality of life compared with those living in residential facilities (Wahl, Iwarsson, and Oswald, 2012).

The present study will evaluate the influence of morbidity on functional health status over a five-year period, with considerations made for the role of physical activity in clarifying this relationship. In addition, the study will evaluate the role of physiological (i.e., body pain intensity), social (i.e., social contact frequency), and physical environment characteristics (i.e., neighborhood quality) as moderating the relationship between morbidity status and physical activity frequency. Only older adults presenting as functionally independent (i.e., no reported functional limitations) at baseline are included in the analysis as the research focus is on disability prevention.

Results from this study may help guide researchers, policy makers, and interventionists in identifying and successfully leveraging elements of the environments that older adults routinely access to help this population achieve optimal functional health over extended periods and prevent or delay the onset of functional decline into disability. Specifically, this study intends to clarify how physiological, social, and physical environment characteristics relate to physical activity level, and its implication for functional health status. As a long-term goal, this research seeks to help reveal a path forward in reducing disability prevalence, which may lead to reductions in healthcare expenditures generated by this population.

1.3 Research Questions and Hypotheses

The research questions are as follows:

1. For functionally independent community-dwelling older adults, does number of health conditions (comorbidities) reported at baseline influence functional health status five-years later?

2. **If so…**does physical activity frequency mediate the relationship between baseline morbidity status and five-year functional health status?

3a. **If so…**does the relationship between baseline morbidity status and physical activity frequency five-years later change based on the frequency of interacting with family and friends?

3b. Does the relationship between baseline morbidity status and physical activity frequency five-years later change based on the intensity of perceived body pain?

3c. Does the relationship between baseline morbidity status and physical activity frequency five-years later change based on the quality of the neighborhood that the respondent resides?

To address these questions, the following hypotheses will be tested:

H_1: Functionally independent community-dwelling older adults who endorse having multiple health conditions (comorbidities) at baseline will experience poorer functional health outcomes at the end of five years compared with those who endorse having fewer health conditions.

H$_2$: For functionally independent community-dwelling older adults, the relationship between baseline morbidity status (i.e., having between 0-5 health conditions) and functional health status five years later will be partially mediated by the frequency of physical activity routinely performed (i.e., physical activity frequency).

H$_{3a}$: For functionally independent community-dwelling older adults, the relationship between baseline morbidity status and physical activity frequency five years later will be moderated by frequency of interacting with friends and family (i.e., social contact frequency).

H$_{3b}$: The relationship between baseline morbidity status and physical activity frequency five years later will be moderated by the intensity of perceived body pain (i.e., body pain intensity).

H$_{3c}$: The relationship between morbidity status and physical activity frequency five years later will be moderated by the quality of their immediate neighborhood environment (i.e., neighborhood quality).

CHAPTER 2

LITERATURE REVIEW

2.1 Theoretical Conceptualizations of Disability

Historically, disability has been described as a personal deficit of irreversible quality (Fougeyrollas and Beauregard, 2001). A mechanistic perspective of the human body as machine persisted up until the end of WWII, and guided the medical community's response to disease and disability. Such a view prompted a proliferation of biomedical models delineating the genesis of disability, and generally emphasizing biological determinants of disability above social-environmental context. This view was widely adopted and communicated by leading authoritative bodies, including the World Health Organization through its International Classification of Impairments, Disabilities, and Handicaps (World Health Organization, 1980).

The last half century has witnessed a paradigm shift, with disease and disability coming to be viewed as arising from an intricate system composed of biological, psychological, social and environmental influences (Fougeyrollas and Beauregard, 2001). A stalwart of this paradigm shift, American medical sociologist, Saad Nagi (1965) proposed a model of disability that highlighted the social consequences of disability and included four elements: *Active Pathology*, *Impairment*, *Functional Limitation*, and *Disability*. In the model, disability follows a linear process that is initiated by an *active pathology*, or dysfunction in physiological processes. Eventually, the individual experiences an *impairment* in a body system (e.g., anatomical, physiological, mental), which restricts the individual from performing a physical behavior within a normative range of functioning, or *functional limitation*. Then, *disability* is essentially the expression of a functional limitation within a social context (Nagi, 1965). Nehemow and Lawton (1976) also made considerations for environmental influences on human behavior, and introduced the *environmental docility hypothesis,* which asserted that patterns of behavior arise from the dynamic relationship of personal competence and environmental demand. Specifically, as personal competence increases, an individual becomes less constrained by circumstantial elements in shaping behavior and development (Lawton and Simon, 1968). Thus, this perspective surmised that disability can be explained by a suboptimal person-environment fit, and therefore, may be remedied by increasing the compatibility between personal capabilities and environmental demand.

Fried, Herdman, Kuhn, and Turano (1991) explored the transitional states leading to disablement and introduced the concept of *preclinical disability,* which was framed as a necessary precursor to disability. Preclinical disability is aligned with Nagi's (1965) conception of impairment in that it is characterized by functional loss, but unfolds insidiously. Preclinical disability occurs along a gradient, initially affecting highly demanding tasks, and eventually compromising performance on the least demanding tasks with the onset of complete disability (Fried et al., 1991). In addition, the authors described preclinical disability as manifesting at two levels—compromising global functioning with a task-specific effect, or by asserting a task-specific effect without preventing task completion. Fried et al., (1991) emphasized interventions that target preclinical disability as a method of delaying, and in some cases, preventing future disability.

Verbrugge and Jette (1994) proposed the '*Disablement Process'* model which borrowed elements from both Nagi's model (1965) and the International Classification of Impairments, Disabilities, and Handicaps (WHO, 1980). The *Disablement Process* model retains *pathology,* *impairment, functional limitations,* and *disability* as the primary transitional states of disablement; however, this model then introduces *risk factors*—predisposing characteristics specific to the individual that increase the probability of becoming impaired. In addition, Verbrugge and Jette (1994) hypothesized that *intra*- and *extra-individual factors* mitigate the relationship between functional limitation and disability. This model is comprehensive in that it ascribes relevance to lifestyle habits, psychosocial attributes, social environments, physical environments, and biological processes to describe the causes and consequences of disability. Further, Verbrugge and Jette (1994) acknowledged the bidirectional nature of the disablement process, which was a deviation from previous models that described linear and unidirectional processes. Despite the model's robustness, Stewart (2003) provided a critique of the *Disablement Process* model, and identified several limitations that would need to be addressed to expand the applicability of the model. Specifically, the model suggests that the pathway leading to disability always begins with a preexisting pathology; Stewart (2003) tactfully noted that disability may be initiated by alternative mechanisms including physiologic aging and disuse. The *Disablement Process* model also fails to recognize the influence of chronic disease symptoms and accompanying sequelae on the rate of transition to full disability. Lastly, Stewart (2003) called for defining functional limitations in more precise terms to effectively assess subtle processes. It is important to note that although the *Disablement Process* model has been well-received, it has yet to be generally applied, and therefore, inconsistencies in how disability and related substrates are operationalized create challenges in comparing research findings across studies (Stewart, 2003).

Baltes and Baltes (1990) eschewed negatively-charged interpretations of disability, and insisted on emphasizing the positive aspects of aging by introducing the *Selection, Optimization,* *and Compensation (SOC)* model of successful aging. This model describes strategies that older adults employ to adapt their behaviors to achieve activity goals in spite of functional loss—with *selection* referring to the pursuit of goals that most closely align with their values, *optimization* referring to behavioral and environmental adaptations to increase the probability of achieving a particular goal, and *compensation* demonstrated by the adoption of tools and technologies to achieve a preferred functional outcome (Baltes and Carstensen, 1996). As Carp (1988) asserted nearly three decades ago, well-being across the lifespan depends on the ability to successfully meet life-maintenance and higher-order needs, and therefore, interventions that target disability should maximize achievement of such goals.

2.2 Personal Attributes and Disability *(Age, Gender, and Socioeconomics)*

Existing evidence allude to a differential risk for disability based on age, gender, and socioeconomic status. Unsurprisingly, age has been positively correlated with *Instrumental Activities of Daily Living (IADLs)* disability, *Basic Activities of Daily Living (BADLs)* disability, and mobility disability (Markides, Stroup-Benham, Goodwin, Perkowski, Lichtenstein, and Ray, 1996; Ferrucci, Guralnik, Simonsick, Salive, Corti, and Langlois, 1996; Peek, Ottenbacher, Markides, and Ostir, 2003; Murphy, Zhang, Boudreau, Cawthon, Newman, Tylavsky, Visser, Goodpaster, and Harris, 2013). Avlund, Lund, Holstein, and Due (2004) conducted a secondary analysis on data that examined 1.5-year disability risk in community-dwelling older adults, and found that 80-year old adults had a higher prevalence of mobility disability at follow-up compared with their younger counterparts. The high prevalence of mobility disability observed in the oldest old (aged 85 and above) may partially be attributed to sarcopenia (i.e., age-related muscle loss), which coincides with diminished functional capacity (Murphy et al., 2013).

Conversely, Lawrence and Jette, (1996) failed to detect a relationship between age and IADLs disability; however, assessment occurred over a two-year period, which may have been too brief of an interval to detect an effect. To reconcile conflicting evidence, mobility disability is more discretely measured, whereas evaluations of IADLs disability tend to be more ambiguous and are therefore more vulnerable to extraneous influences that can obscure age effects.

Women enjoy a longer life-expectancy compared with men. For older adults in dyadic relationships, a consequence is that women tend to outlive male partners, which contributes to a sizeable portion of older women living alone—with this being the case for nearly 40% of women in one sample and approximately 30% for men in the same study (Lipman, Lubell, and Salomon, 2012). Further, it has been consistently shown that older women have an elevated disability risk (Unger, Johnson, and Marks, 1997; Spector and Fleishman, 1998; Avlund et al., 2004; WHO, 2011). Paterson et al., (2004) observed twice as many women in their sample had become functionally dependent compared with their male counterparts. Similarly, Strawbridge and colleagues (1996) followed 365 older adults over a six-year period, and found that older men were more likely to be aging successfully—as defined by independence on 13 activity and mobility measures and five physical performance scales. Studies have shown that following a fall incident, older women are more likely to experience functional decline compared with men (Stel et al., 2004). Older women also experience greater challenges from such tasks as ascending/ descending stairs and walking a half mile (Peek et al., 2003; Visser, Simonsick, Colbert, Brach, Rubin, Kritchevsky, Newman, and Harris, 2005). However, the time-course for transitioning to disability is comparable for men and women, with women typically living longer once disabled (Ferrucci et al., 1996). Conversely, men have more severe disability, which contributes to early mortality (Spector and Fleishman, 1998).

Disability outcome is also influenced by socioeconomic status (SES), with lower-income older adults showing increased odds for functional decline (Lipman, Lubell, and Salomon, 2012). More broadly, area-level SES has been inversely related to functional disability (Philibert, Pampalon, and Daniel, 2015). Evidence also demonstrates that impoverished older adults are less adept at adapting their behaviors to apply optimization strategies to overcome functional limitations and achieve activity goals (Lang, Rieckmann, and Baltes, 2002).

2.3 Comorbidity and Disability Risk

The *'Disablement Process'* model describes disability as initiated by existing pathology. This proposition has garnered support, with several studies revealing positive associations between morbidity status and functional disability risk (Verbrugge, Reoma, and Gruber-Baldini, 1994; Fried et al., 1997; Stuck et al., 1998). Specifically, Stuck and colleagues (1998) reviewed disability outcome research published between 1985-1997, and concluded that having at least one chronic health condition predicted functional decline, and that risk of decline increased with the presence of multiple health conditions (i.e., comorbidity). However, none of the studies assessed disease severity, which may uniquely influence rate of functional decline. Further, many of the studies demonstrated conceptual overlap between functional limitation and disability, which makes it difficult to apply the classification scheme introduced by Verbrugge and Jette (1994). More recently, Ralph, Mielenz, Parton, Flatley, and Thorpe (2013) conducted a survey of 1,016 older adults and obtained similar results, with individuals diagnosed with multiple health conditions at greater odds of reporting a co-occurring functional limitation compared with individuals who endorsed a single condition, and this effect was strongest for those aged 75 and above. This study assessed for five health conditions (i.e., arthritis, osteoporosis, hypertension, hypercholesterolemia, diabetes), and therefore, it is possible that the study sample presented with other conditions that may have affected functional capacity, but not captured through data collection. In addition, causal interpretations cannot be explored as the study used cross-sectional data.

Previous investigations have also identified associations between Parkinson's disease, cerebrovascular disease, and respiratory diseases and mobility disability (Boult, Kane, Louis, Boult, and McCaffrey, 1994; Gijsen, Hoeymans, Schellevis, Ruwaard, Satariano, and van den Bos, 2001; Peek et al., 2003). Boult et al., (1994) conducted a secondary analysis of data from the Longitudinal Study of Aging (LSOA), and identified cerebrovascular disease (OR = 2.14; 95% CL = 1.16, 3.98), and arthritis (OR = 1.51; 95% CL = 1.08, 2.11) as the strongest predictors of functional capacity. A strength of this study is that functional limitations in both IADLs and BADLs were assessed; however, data was gathered via self-report alone, which may be prone to inaccuracies in reporting functional health statuses. Interestingly, diabetes and cancer predicted mortality risk, but did not predict functional disability (Boult et al., 1994). In addition, Markides et al., (1996) observed that stroke, heart attack, and hip fracture were associated with diminished functional capacity.

Gijsen and colleagues (2001) reviewed literature on causes and consequences of comorbidity, which consistently indicated that comorbidity impacts functional capacity; however, the strength of this effect varied by disease combination. Perhaps more compelling is the finding that older adults presenting in a diseased state at baseline were four times more likely to report a disability at eight-year follow-up compared with their healthy counterparts (Paterson, Govindasamy, Vidmar, Cunningham, and Koval, 2004). The authors noted that as the study only contained two assessment points (i.e., baseline, 8-year), they were limited in considering other life events that may have affected disability outcomes (Paterson et al., 2004). Importantly, for all studies reported on thus far, only older adults who were functionally independent at baseline were included in the respective analyses. Alternately, Lau, Parikh, Harvey, Huang, and Farias (2015) sampled older adults with a range of functional capacity levels, and found that older adults who endorsed severe functional limitations at baseline were at nearly four times greater odds of future IADL disability. Lastly, although most studies assessed health conditions via self-report, previous work has found consistent agreement between patient self-report and medical diagnoses (Kriegsman, Penninx, Eijk, Boeke, and Deeg, 1996).

2.4 Physiological Changes and Aging

Sarcopenia—defined as low muscle mass with low muscle strength and/ or low muscle performance, is a phenomenon that is often cited as a precursor to disability (Janssen, Heymsfield, and Ross, 2002; Murphy, Ip, Zhang, Boudreau, Cawthon, Newmann, Tylavsky, Visser, Goodpaster, and Harris, 2013). Evidence from a longitudinal study conducted over a nine-year period suggests that greater appendicular lean muscle at baseline is related to a reduced risk of developing sarcopenia (Murphy et al., 2013). In addition, women are disproportionately affected by sarcopenia (Janssen, Heymsfield, and Ross, 2002). Susceptibility to late-life disability also appears to be visible during early development (Suomi, 1997). Specifically, low birth weight is correlated with grip strength in older adulthood, which has consistently been shown to predict disability risk (Sayer, Syddall, Martin, Patel, Paylis, and Cooper, 2008). Body Mass Index (BMI), oxidative stress levels, and inflammation have been shown to influence transitions to sarcopenia (Stuck et al., 1998; Sattelmair, Pertman, and Forman, 2009). Karlamangla, Singer, McEwen, Rowe, and Seeman (2002) found allostatic load—or wear and tear of body mechanisms induced by chronic stress, to inversely relate to physical performance, with greater allostatic load foreshadowing diminished functional capacity.

2.5 Benefits of Physical Activity

Physical exercise confers numerous health benefits across the lifespan, and has been associated with transitioning away from sarcopenia to more normative lean muscle states, improved cardiovascular capacity, as well as a reduced risk of morbidity, mortality, and loss of independence in older adulthood (Paterson et al., 2004; Paterson and Warburton, 2010). The Center for Disease Control and Prevention (2013) recommends that to achieve significant health benefits, older adults should engage in 150 minutes of moderate-to-vigorous intensity aerobic activity per week, and strength training on a minimum of two days over the same timeframe.

Despite its health benefits, less than three-percent of older adults (aged 60+) routinely achieve sufficient levels of physical activity (Troiano, Berrigan, Dodd, Masse, Tilert, and McDowell, 2008), and older women are considered the least active cohort (Santos, Silva, Baptista, Santos, Vale, Mota, and Sardinha, 2012). Researchers have observed a dose-response relationship between physical activity and disability risk, with greater activity expenditures associated with a reduced risk for disability (Paterson and Warburton, 2010). Similarly, Unger and colleagues (1997) analyzed data from the LSOA study of more than 7,000 respondents who were followed over a six-year period, and found that older adults who engaged in moderate-to-vigorous physical activity delayed the rate of functional decline. Furthermore, physical activity attenuated the deleterious effect of widowhood on functional capacity, with this benefit being stronger for older men than women. However, activity expenditures were obtained through self-report, which tend to be artificially inflated in this population (Troiano et al., 2008). Santos and colleagues (2012) used accelerometers to objectively assess activity expenditures in their sample of 314 older adults (aged 65-103), which revealed that both activity expenditures and sedentary time uniquely contribute to disability risk, which suggests that simply achieving recommended levels of physical activity may be necessary, but insufficient to achieve adequate health benefits, especially for individuals who lead a predominantly sedentary lifestyle.

Routine engagement in physical activity has also been shown to increase self-efficacy for functional tasks, which may mediate the relationship between physical activity and functional capacity (Mullen, McAuley, Satariano, Kealey, Prohaska, 2012). Alternately, a hypothesized pathway connecting physical activity and functional health outcomes is by increasing upper and lower body strength and performance (Cress, Buhner, Questad, Esselman, deLateur, and Schwartz, 1999; Vermeulen, Neyens, van Rossum, Spreeuwenberg, and de Witte, 2011). Specifically, Cress and colleagues (1999) randomly assigned 49 older adults to either an exercise intervention or control, and followed them over a six-month period to examine changes to body composition and physiology. Results revealed that volunteers assigned to the exercise intervention displayed greater maximum oxygen consumption and muscle strength. Furthermore, functional fitness scores significantly improved from baseline scores, but only for the exercise intervention group, which suggests that functional decline is reversible (Cress et al., 1999). At least one study found that muscle parameters (i.e., muscle strength, muscle mass, muscle attenuation) did not mediate the relationship between physical activity and functional capacity (Visser, Simonsick, Colbert, Brach, Rubin, Kritchevsky, Newman, Harris, 2005). However, knee extensor strength partially mediated the relationship between physical activity and mobility disability, but this was the case for women only (Visser et al., 2005).

Cognitive status has also been inversely related to BADL disability risk (Gill, Williams, Richardson, and Tinetti, 1996). Further, performance on a range of executive function measures predicted mobility disability outcomes at 12-month follow-up, with physical activity shown to enhance cognitive functioning (Goethe, Fanning, Awick, Chung, Wokcicki, Olson, Mullen, Voss, Erickson, Kramer, and McAuley, 2014).

Although clear evidence consistently demonstrates a relationship between physical activity and several dimensions of disability, the variability in which physical activity and disability are operationalized make it difficult to draw general conclusions about potential mediating variables (Vermeulen et al., 2011). Despite this limitation, there is consensus for the conclusion that physical activity mitigates age-related changes to human physiology, thereby reducing the rate of biological aging (Sattelmair, Pertman, and Forman, 2009).

2.6 Social Environment and Disability Risk

Disability does not develop in isolation, rather it arises from a confluence of factors—with the social environment playing a substantial role in the disablement process. Growing evidence indicates that the social environment makes an important contribution to disability risk in older adulthood (Stuck et al., 1998). Generally, socially active older adults report a lower incidence of disability (Mendes de Leon, Gold, Glass, Kaplan, and George, 2001; Mendes de Leon, Glass, and Berkman, 2003; Zunzunegui, Rodriguez-Laso, Otero, Pluijm, Blumstein, Jylha, Minicuci, and Deeg, 2005). Unger and colleagues (1997) followed older adults over a six-year period, and those who endorsed high levels of social engagement were the least likely to report functional disability at follow-up. Social-ties type also appears to matter, with family and friend relations shown to buffer against late-life disability, with the caveat being diminishing returns of this salutogenic effect with increasing age (Zunzunegui et al., 2005; Mendes de Leon, Glass, and Berkman, 2003). In addition, social network size has been inversely correlated with disability risk (Mendes de Leon et al., 2001). Older adults with five or more social contacts are more likely to maintain functional independence for longer periods compared with those with few social contacts (Verbrugge, Reoma, and Gruber-Baldini, 1994; Strawbridge et al., 1996). Large social networks have also been associated with increased odds of recovering from disability (Mendes de Leon, Glass, Beckett, Seeman, Evans, and Berkman, 1999; Mendes de Leon et al., 2001). Furthermore, for older adults who present with a chronic health condition at baseline, a large social network has been associated with a slower rate of functional decline (Bisschop, Kriegsman, van Tilburg, Penninx, van Eijk, and Deeg, 2003).

Social isolation in older adulthood has been linked to several negative health outcomes including high blood pressure, cognitive decline, depression, functional disability, and mortality (Bassuk, Glass, and Berkman, 1999; Berkman, Glass, Brissette, and Seeman, 2000). James, Boyle, Buchman, and Bennett (2011) examined the influence of social contact on several dimensions of disability, and found that the relative risk of disability decreased by 46%, mobility disability decreased by 35%, and IADLs disability decreased by 35% for every one-point increase in social contact frequency.

Glass and colleagues (1997) examined the structural characteristics of older adults' social networks, and concluded that their networks are comprised of four domains: ties with children, ties with other close relatives, ties with friends, and ties with a confidant. However, social ties type, network size, and frequency of social engagement do not appear to be the only aspects of the social environment that influence disability risk, with social support type (i.e., emotional, instrumental) also emerging as a determinant of disability risk.

Peek et al., (2003) observed an inverse relationship between emotional support and mobility disability. Emotional support has also been positively correlated with cognitive and physical performance (Seeman, Bruce, and McAvay, 1996). Conversely, instrumental support poses a detriment to functional capacity, with greater levels of instrumental support associated with an increased risk of future disability; this trend being strongest among older adult men (Seeman, Bruce, and McAvay, 1996; Mendes de Leon et al., 1999; Mendes de Leon et al., 2001). Older men aged 80 and above who are recipients of instrumental support have an elevated risk of disability (Avlund, Lund, Holstein, and Due, 2004). Seeman et al., (1996) suggested that for older men, it is more probable that instrumental support is a byproduct of diminishing capabilities, rather than a trigger of disability.

2.7 Physical Environment and Disability Risk

Physical environments are often regarded as enablers of and/ or barriers to physical and functional performance (Cunningham and Michael, 2004; Haselwandter, Corcoran, Folta, Hyatt, Fenton, and Nelson, 2015). Supportive and barrier-free environments have been viewed as crucial to aging successfully, and as one approach to circumvent functional limitations (Clarke and Nieuwenhuijsen, 2009). Nearly five decades ago, Lawton and Simon (1968) observed evidence for the environmental docility hypothesis, with independent living older adults adapting their behavior to environmental constraints to achieve life goals. Fisk, Rogers, Kelly, and Fausset (2011) identified strategies that older men employ upon encountering environmental and task-specific adversity. Specifically, older men exerted great effort to persevere on a task, but if their efforts went unrewarded, they either discontinued the task, or transitioned to a living environment that better accommodated diminishing capabilities. Conversely, older women tend to encounter more challenges in the physical environment compared with men—encountering on average four more issues (Gitlin, Mann, Tomit, and Marcus, 2001). Most challenges older adults encounter occur in the bathroom, kitchen, and bedroom (Gitlin et al., 2001).

Physical environments also influence activity expenditures, with community-dwelling older adults typically achieving higher levels of physical activity compared with their institutionalized peers, which remains the case after adjusting for functional capacity (Krol-Zielinksa, Kusy, Zielinski, and Osinski, 2011). For older adults with preexisting impairments, street quality has been shown to influence the severity of mobility disability (Clarke, Ailshire, Bader, Morenoff, and House, 2008). Mann, Ottenbacher, Fraas, Tomita, and Granger (1999) found that providing community-dwelling frail older adults with an appropriate combination of assistive technologies and environmental modifications decelerated rates of functional decline. In addition, older adults remained in their homes for longer periods with improved functional health outcomes. Healthcare-related expenses were less costly as this group was less likely to require institutionalized care—which tends to consume considerable resources (Mann et al., 1999). Supporting older adults as they strive to age-in-place will require the implementation of universal design principles to create living environments that can support the needs of diverse functional capacity levels (Carr, Weir, Azar, and Azar, 2013).

2.8 Study Scope

As a multidimensional concept, disability can refer to reductions to globular functional capacity or it may be task-specific—with both cases embedding disability within a social context (Fried et al., 1991). Older adults experience a high prevalence of disability, with those presenting with comorbid chronic health conditions being at greatest risk for future disability (Stuck et al., 1998). Previous research has demonstrated that disability risk is influenced by multiple factors including personal attributes, lifestyle habits, social environments, and the built/ physical environment (Haselwandter et al., 2015). However, most studies have examined these factors in isolation, which has yielded unidimensional interpretations of their impact on functional health outcomes. Further, the relationship between morbidity status and functional health is well-documented, but less is known about the role that physical activity may play in mediating this relationship. Specifically, physical activity has been viewed as preventing both disease and disability, however, for older adults presenting with preexisting health conditions, it will be important to determine if physical activity confers similar health benefits. Therefore, a next step is to explore characteristics of the person, social, and physical environments as they relate to physical activity, and consider how they may attenuate any effect that morbidity status may have on one's likelihood of engaging in physical activity, and implications for functional health outcomes.

The study purpose is to examine the relationship between baseline morbidity status, physical activity frequency, and the five-year functional health status of community-dwelling older adults who present as functionally-independent at baseline. Further, this study seeks to clarify the contributions made by the social and physical environment in influencing levels of physical activity in this population. Lastly, given that older adults who present with health conditions may also experience accompanying body pain, it will be relevant to evaluate the influence of body pain intensity on physical activity levels. The primary outcome variables of interest are functional health status at five-year follow-up, as measured by Basic Activities of Daily Living (BADLs) performance (e.g., walking across a room, bathing, dressing), and physical activity frequency at five-year follow-up.

CHAPTER 3

METHODS

3.1 Pilot Ethnographic Study

To explore built environment characteristics that promote and/or detract from an active lifestyle in older adulthood, in-person interviews were conducted during Spring 2016 with eight functionally independent community-dwelling older adults (six women) aged 65-74 (M = 68, SD = 3.5) living in upstate New York, who reported engaging in routine physical activity (defined as three or more times per week). The sample was recruited from senior community centers and via snowball sampling. A semi-structured interview protocol was enacted, with interview questions informed by existing literature relevant to the topics of aging and the built environment. This study was approved by the Cornell University Institutional Review Board (#1604006302).

Although emphasis was initially placed on physical environment design, for this sample, the social environment emerged as a key indicator of one's likelihood of achieving routine physical activity. Specifically, most respondents noted that they evaluate physical activities based on the opportunities for socialization, and are motivated for physical activities that are also socially engaging. Although this sample largely viewed health, well-being, and the ability to remain living independently as their greatest assets, in considering the role of physical activity in their lives, they were more focused on how such activities enhance the lived experience and support social interaction. Several respondents also described health conditions that they have been diagnosed with, and concerns they had with leading an active lifestyle, while also accommodating a compromised health status. Preliminary findings from the ethnographic study inspired the present thesis project.

3.2 NSHAP Overview

The thesis project was a secondary analysis using data from Wave 1 and Wave 2 of the National Social Life, Health, and Aging Project (NSHAP). The thesis project was approved by the Cornell University Institutional Review Board (#1611006754). For the present study, researchers submitted a user agreement to the Inter-University Consortium for Political and Social Research, and were granted data access to NSHAP. The researchers then obtained a data security plan from the Cornell Restricted Access Data Center (CRADC).

The National Social Life, Health, and Aging Project is a longitudinal survey study comprised of a nationally representative sample of 3,005 (1,550 women) US community-dwelling adults aged 57-85. Researchers associated with NSHAP implemented a multistage area probability sampling design, whereby 1) geographic areas were selected into the sample, 2) households from within the specified area were identified, and 3) individuals within a household were recruited for interviews. Respondents were screened by the Institute for Social Research for the Health and Retirement Study (HRS) prior to being considered for the NSHAP survey study, with African American and Hispanic groups oversampled to obtain a diverse cohort representative of the larger population (O'Muircheartaigh, Eckman, and Smith, 2009). The NSHAP survey study collected data on several dimensions of older adult health, including psychological, biological, social, and environmental characteristics. The National Opinion Research Center (NORC) and researchers at the University of Chicago performed data collection in two waves, with Wave 1 (W1) occurring from 2005-2006 (weighted response rate = 75.5%), and Wave 2 (W2) occurring from 2010-2011, with 2,261 returning respondents with a weighted response rate = 88.8% (Waite, Cagney, Dale, Huang, Laumann, McClintock, O'Muircheartaigh, Schumm, and Cornwell, 2014). All interviews were conducted face-to-face at respondents' residence or an alternate location (e.g., café). To minimize respondent burden, the survey was modularized with respondents randomly assigned to complete certain sections during the face-to-face interview, and the remaining sections in a leave-behind questionnaire that they were instructed to return to NORC via postal mail. Data are publicly available (NSHAP Wave 1: Waite, Linda J., Edward O. Laumann, Wendy Levinson, Stacy Tessler Lindau, and Colm A. O'Muircheartaigh. National Social Life, Health, and Aging Project (NSHAP): Wave 1. ICPSR20541-v6. Ann Arbor, MI: Inter-university Consortium for Political and Social Research [distributor], 2014-04-30. Doi: 10.3886/ICPSR20541.v6. NSHAP Wave 2: Waite, Linda J., Kathleen Cagney, William Dale, Elbert Huang, Edward O. Laumann, Martha K. McClintock, Colm A. O'Muircheartaigh, L. Philip Schumm, and Benjamin Cornwell. National Social Life, Health, and Aging Project (NSHAP): Wave 2 and Partner Data Collection. ICPSR34921-v1. Ann Arbor, MI: Interuniversity Consortium for Political and Social Research [distributor], 2014-04-29.doi:10.3886/ICPSR34921.v1.).

3.3 Hypotheses and Conceptual Framework

In the present study, a secondary analysis was performed using cross-sectional and five-year longitudinal survey data from the NSHAP W2 dataset, with morbidity status lagged from the W1 dataset. The aims of the present study are 1) verify the relationship between morbidity status and functional health outcome over a five-year period, 2) evaluate physical activity as a mediator to this relationship, and 3) explore factors endemic to older adulthood that may moderate the effects of morbidity status on physical activity frequency, including body pain intensity, social contact frequency, and neighborhood quality.

Corresponding to the above aims, the following research questions will be addressed:

1. For functionally independent community-dwelling older adults, does number of health conditions reported at baseline influence functional health status at the end of five years?

2. **If so…**does physical activity frequency mediate the relationship between baseline morbidity status and five-year functional health status?

3a. **If so…**does the relationship between baseline morbidity status and physical activity frequency at five-year follow-up change based on the frequency of interacting with family and friends?

3b. Does the relationship between baseline morbidity status and physical activity frequency at five-year follow-up change based on the intensity of perceived body pain?

3c. Does the relationship between baseline morbidity status and physical activity frequency at five-year follow-up change based on the quality of the neighborhood that the respondent resides?

To respond to the research questions and study aims, a conceptual model is proposed (Figure 3-1) with the following hypotheses to be tested:

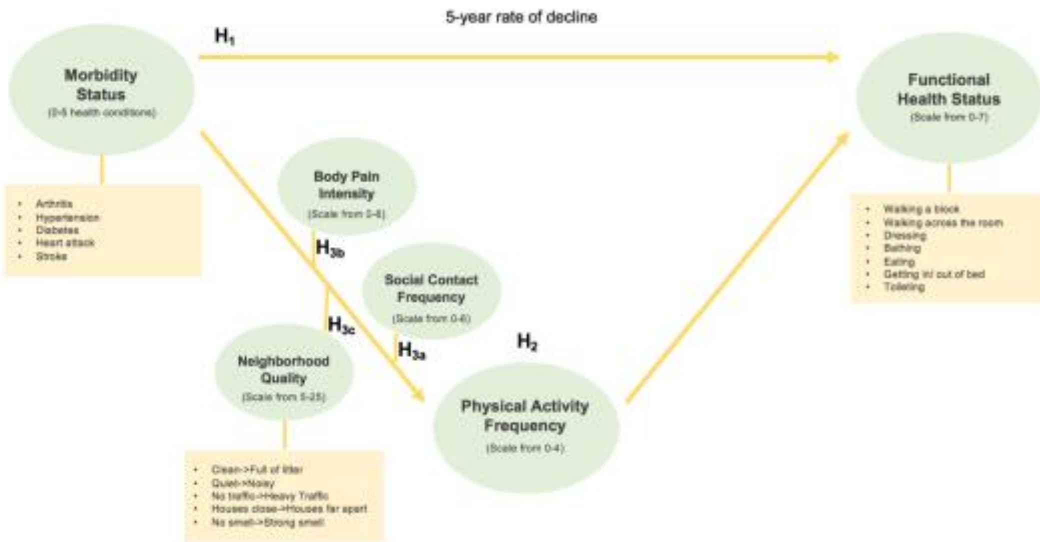

Figure 3-1: Conceptual Framework

H_1: Functionally independent community-dwelling older adults who endorse having multiple health conditions (i.e., morbidity status) at baseline will experience poorer functional health outcomes (i.e., functional health status) at the end of five years compared with those who endorse having fewer health conditions.

H_2: For functionally independent community-dwelling older adults, the relationship between baseline morbidity status and functional health status five years later will be partially mediated by the frequency of engaging in physical activity (i.e., physical activity frequency).

H_{3a}: For functionally independent community-dwelling older adults, the relationship between baseline morbidity status and physical activity frequency five years later will be moderated by frequency of interacting with friends and family (i.e., social contact frequency).

H_{3b}: The relationship between morbidity status and physical activity frequency five years later will be moderated by the intensity of perceived body pain (i.e., body pain intensity).

H_{3c}: The relationship between morbidity status and physical activity frequency five years later will be moderated by the quality of their immediate neighborhood environment (i.e., neighborhood quality).

3.4 Sampling and Study Population

The following additional sampling procedures were performed on the NSHAP datasets by researchers of the present study. Respondents aged 65 and above, functionally independent (i.e., reporting no difficulties with performing seven BADLs), and having been assessed at both W1 and W2 of the NSHAP study were included in the present analyses. The inclusion criteria for this study reflected the aims and the scope to model five-year functional health outcomes in older adults who were functionally independent at baseline assessment i.e., only respondents who self-reported a status of no functional dependence at baseline, which marked the beginning of the five-year study period. As such, the final sample size was reduced to 918 respondents (Figure 3-2). The final sample includes adults who were aged 65-85 at W1 (M = 72.6, SD = 5.4), with 51.3% female, and 74.9% identifying themselves as white/ Caucasian. Most respondents had received at least a high school diploma (82.0%), with 22.7% of these reporting having completed a bachelor's degree or greater. In addition, 61.2% of the sample was married or living with a partner. Average annual household income for the sample was $35,380 (*SD* = $77,721).

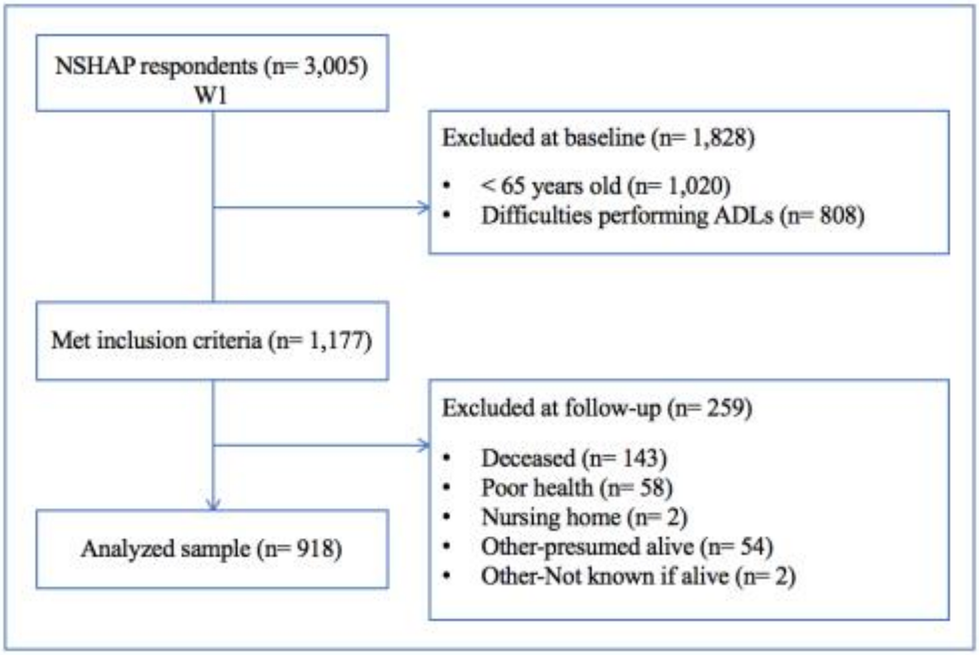

Figure 3-2: CONSORT Flow Diagram

3.5 Measures and Covariates

3.5.1 Morbidity Status Assessment (Lagged-W1)

The NSHAP surveys contain questions related to chronic health conditions that typically emerge in older adulthood, with the protocol modified slightly from W1 to W2 (Waite et al., 2014). Specifically, for W1, the interviewer posed the following question, "*Has a medical doctor told you that you have* [**condition**]?", and thereafter enumerated all health conditions on the form, and marked each condition that the respondent endorsed. For W2, the interviewer introduced each health condition through separate questions, and posed follow-up questions to clarify respondents' answer choices (Waite et al., 2014). As an example, for respondents who endorsed having been diagnosed with a cardiovascular condition, the interviewer would then ask questions to specify condition type (e.g., coronary heart disease, heart attack).

For the secondary analysis, five health conditions were considered including: arthritis, hypertension, diabetes mellitus, heart attack, and stroke, which were all assessed at W1 of the NSHAP study. Researchers in the present study were interested in these specific diseases as they have been associated with functional health outcomes in previous studies, and emerged as the most prevalent health conditions in the subsample that is being used for the secondary analysis (Markides et al., 1996; Ralph et al., 2013). To derive baseline morbidity status scores, researchers in the present study summated the number of health conditions endorsed at baseline, with this number ranging from zero to five (0-5).

3.5.2 Physical Activity Frequency Assessment (W2)

Researchers in the NSHAP study assessed physical activity frequency at W1 with a single question i.e., "*How often do you participate in physical activity such as walking, dancing, gardening, physical exercise or sports?*" (O'Muircheartaigh, Eckman, and Smith, 2009). Response choices included five categories (i.e., Never, Less than 1 time per month, 1-3 times per month, 1-2 times per week, 3 or more times per week). For W2 of the NSHAP study, the question was modified to read, "*On average, over the last 12 months, how often have you participated in vigorous physical activity or exercise? By vigorous physical activity, we mean* <u>30 MINUTES OR MORE</u> *of things like sports, exercise classes, heavy housework, or a job that involves physical labor"* (Waite et al., 2014). In addition, response choices were expanded from four for W1 to five for W2 (i.e., Never, Less than 1 time per month).

For the secondary analysis, several responses were combined into a single category for W2 data i.e., "*5 or more times per week*" and "*3 or 4 times per week*" became one category, which enabled for comparisons with W1 data. Similar numerical values were then assigned to response choices for both W1 and W2, from 0-4, with higher scores indicative of more frequent physical activity (Never = 0; Less than 1 time per month = 1; 1-3 times per month = 2; 1-2 times per week = 3; 3 or more times per week = 4). Physical activity frequency at W2 is used for the main analyses, while physical activity frequency at W1 is included to examine correlations between baseline and year five scores.

3.5.3 Social Contact Frequency Assessment (W2)

In the NSHAP study, researchers assessed social contact frequency at both W1 and W2, and this variable was assessed with the following question, "*In the past 12 months, how often did you get together socially with friends or relatives?"* (O'Muircheartaigh, Eckman, and Smith, 2009). Response options included: Never, Less than once a year, About once or twice a year, Several times a year, About once a month, Every week, Several times a week. Researchers in the NSHAP study assigned similar numerical values to response options for both W1 and W2, from 0-6, with higher scores indicative of more frequent social contact [Never = 0; Less than once a year = 1; About once or twice a year = 2; Several times a year = 3; About once a month = 4; Every week = 5; Several times a week = 6] (O'Muircheartaigh, Eckman, and Smith, 2009).

For the secondary analysis, researchers elected to use social contact frequency at W2 for the main analyses, while social contact frequency at W1 is included to examine correlations between baseline and year five scores.

3.5.4 Body Pain Intensity Assessment (W2)

Researchers in the NSHAP study did not assess the intensity of perceived body pain at W1, but they did assess it at W2, with respondents instructed to rate the intensity of body pain that they have experienced in the four weeks that preceded the interview session (Waite et al., 2014). Response choices included: No pain, Slight pain, Mild pain, Moderate pain, Severe pain, Extreme pain, The most intense pain imaginable. Response choices were assigned numerical values from 0-6, with higher scores indicating more intense perceived body pain (No pain = 0; Slight Pain = 1; Mild Pain = 2; Moderate pain = 3; Severe Pain = 4; Extreme pain = 5; The most intense pain imaginable = 6). This classification and scoring system remained unchanged for the secondary analysis.

3.5.5 Neighborhood Quality Assessment (W2)

Researchers in the NSHAP study did not assess respondents' neighborhood environment at W1, but they did assess it at W2, with interviewers instructed to provide ratings of the immediate neighborhood block on which the respondent resided, and these ratings were to be completed after each interview session (Waite et al., 2014). Interviewers in the NSHAP study assessed five dimensions of the neighborhood block including: cleanliness, noise intensity, traffic density, neighborhood density, and air pollution. Each dimension was on a scale numbering 1-5.

For the secondary analysis, the neighborhood density item has been reverse-coded so that higher values are indicative of greater neighborhood density, which has been proposed by Cornwell and Cagney (2014). The dimensional scale rating was summed to derive an overall score of neighborhood quality, with initial scores ranging from 5-25, and lower scores indicative of better quality neighborhoods. As the original data for the subsample violated the statistical assumption of normality, A log transformation was made to the data, with new scores ranging from 1.6-2.9; lower scores indicative of better quality neighborhoods.

3.5.6 Functional Health Status Assessment (W2)

Researchers in the NSHAP study assessed functional health status at both W1 and W2, using seven items from the Activities of Daily Living scale (Waite et al., 2014). Specifically, respondents were instructed to indicate the difficulty they experienced while performing a range of activities including: a) walking across a room, b) walking a city block, c) dressing, d) bathing, e) eating, f) getting in and out of bed, and g) toileting. Further, respondents were instructed to avoid reporting on any difficulties that they believed would last less than three months i.e., temporary disability (O'Muircheartaigh, Eckman, and Smith, 2009). Therefore, responses were based on four options (no difficulty, some difficulty, much difficulty, unable to do).

For the secondary analysis, I adopted the scoring criteria first proposed by Huisingh-Scheetz, Kocherginsky, Schumm, Engelman, McClintock, Dale, Magett, Rush, and Waite (2014), where one point is assigned to each activity that the respondent reports "no difficulty" in performing. Respondents do not receive a point if they report any level of difficulty in performing the activity, with scores then summed across activities to derive a global functional health score. In addition, I omitted two items from the ADLs scale used in the NSHAP study (i.e., day driving and night driving) as their inclusion would have dramatically reduced the final sample size. Total scores range from 0-7, with higher scores indicative of better functional health. Only data for respondents who achieved a score of seven at baseline assessment (i.e., functionally independent) were included in the secondary analysis.

3.5.7 Other Covariates

For the secondary analysis, basic demographics are adjusted for as potential confounders. Specifically, age was controlled for as it has previously been found to correlate with functional health status (Avlund et al., 2004). To assess morbidity prevalence, age was distilled along three categories which included: young-old (aged 65-71; n = 453), old (aged 72-78; n = 318), and oldest-old (aged 79-85; n = 147). These categories closely resemble elderly subpopulations proposed by Avlund et al (2004). The influences of racial background and educational attainment were also considered, where categories for race included: White, Black, Hispanic, Asian, Other. Categories for educational attainment included: Less than a high school diploma, high school diploma, some college, bachelor’s degree or higher. Annual household income was also considered as a proxy measure for socioeconomic status.

In addition, gender has been included as a covariate in the primary analyses as its relationship to functional health outcome is well-documented (Murphy et al., 2013). Acknowledging the significance of gender in morbidity and disability research, the present study compared morbidity prevalence across gender. However, the researcher decided against conducting further analyses into this variable. Specifically, such analyses would have been outside the scope of the study aims, and may have inadvertently detracted from the primary focus, which was on the role that morbidity status and physical activity frequency play in five-year functional health outcome in older adulthood. This decision is reflected in subsequent sections of this manuscript.

3.6 Statistical and Data Analysis

To estimate the relationships between key variables of interest, Pearson's correlation coefficients were computed with ($\alpha = .05$). To test H_1, a simple linear regression analysis was performed to evaluate the relationship between baseline morbidity status and functional health status at five-year follow-up. To test H_2, a multiple linear regression analysis was performed to evaluate the relationship between baseline morbidity status and functional health status (at year five) while controlling for physical activity frequency (at year five). In addition, to test H_{3a-c}, multiple linear regression analyses were performed to evaluate the relationship between baseline morbidity status and physical activity frequency at the end of a five-year period, while adjusting for social contact frequency, body pain intensity, neighborhood quality, and all relevant covariates.

3.7 Ancillary Analysis

A simple linear regression analysis was performed to evaluate the relationship between specific baseline health conditions (e.g., arthritis, hypertension) and functional health status over a five-year period. In addition, a similar analysis was taken to evaluate the relationship between baseline health conditions and physical activity frequency at the end of a five-year period.

Person-level weights were applied to the analyses to account for non-responses. All statistical analyses were completed using Stata Version 14.2 (StataCorp, 2015).

CHAPTER 4

RESULTS

4.1 Subsample Information

At W1, the mean age for the subsample was 72.56 years (*SD = 5.35*), with all respondents reporting functional independence in the seven ADL domains of interest. Overall, the age distribution skews slightly younger, with 49.35% of the subsample belonging to the young-old category, 34.64% belonging to the old, and 16.01% belonging to the oldest-old group.

Hypertension emerged as the most prevalent health condition, with 56.86% of the sample reportedly having been diagnosed. Both older women and men had comparable rates of hypertension at 57.3% and 56.4%, respectively. Arthritis emerged as the second commonest health condition, which 45.32% of the sample reported. Older women endorsed a higher prevalence of arthritis (51.6%) compared with older men (38.7%). For both women and men, the prevalence of endorsing a diagnosis of arthritis increased for successive age groups (Table 4-1). Approximately 16% of the sample endorsed a diagnosis of diabetes, with 51.4% being older men. Less than a tenth of respondents endorsed having suffered a heart attack (9.37%), with

	Women						Men					
	65-71		72-78		79-85		65-71		72-78		79-85	
	n = 229		*n* = 164		*n* = 78		*n* = 224		*n* = 154		*n* = 69	
Condition	*%*	*SE*	*%*	*SE*	*%*	*SE*	*%*	*SE*	*%*	*SE*	*%*	*SE*
Arthritis	46.3	.03	54.3	.04	61.5	.06	33.9	.03	42.2	.04	46.4	.06
Diabetes	18.3	.03	10.9	.02	15.4	.04	16.9	.03	18.8	.03	13.0	.04
Heart Attack	6.6	.02	5.5	.02	2.6	.02	9.4	.02	17.5	.03	17.4	.05
Hypertension	49.8	.03	65.2	.04	62.8	.05	56.7	.03	56.5	.04	55.1	.05
Stroke	4.4	.01	6.7	.02	8.9	.03	4.0	.01	8.4	.02	10.1	.04

Table 4-1: Morbidity Prevalence by Age and Gender

69.8% being older men. Relatively few respondents endorsed having suffered a stroke (6.21%).

To explore the issue of comorbidity, or having multiple health conditions, which was one of the main variables in all hypotheses, the proportions of the subsample endorsing between 0-5 health conditions (based on the NSHAP Study scale) are displayed in Table 4-2. The most common endorsement was for one health condition, endorsed by 38.56% of the sample, followed by two health conditions (28.54%), and no health conditions (21.02%). Approximately 11.6% of the sample endorsed having three or more health conditions.

4.2 Magnitude of Associations

Over the five-year period, the sample's functional health status decreased from a baseline score of 7 (functional independence) to 6.49 ($SD = 1.13$). Physical activity decreased from 3.57 ($SD = .94$) to 2.54 ($SD = 1.65$), and social engagement frequency decreased from 3.39 ($SD = 3.29$) to 3.14 ($SD = 3.36$), see Table 4-3.

A Pearson's correlation was performed on several variables of interest to examine associations between the variables, and for the variables that had an association, to determine the strength of the relationship. As displayed in Table 4-3, the number of health conditions (i.e., comorbidity) and functional health outcome had a very weak negative correlation $r(916) = -.17$, $p < .001$. Physical activity level at 5-year follow-up and functional health outcome had a positive yet weak correlation $r(916) = .30$, $p < .001$. Number of health conditions (at baseline) and physical activity (at year five) had a negative and weak correlation $r(916) = -.20$, $p < .001$. Social contact frequency (at year five) and physical activity frequency (at year five) had a very weak positive correlation $r(916) = .11$, $p = .001$. Pain level intensity (at year five) and physical activity frequency (at year five) were not correlated $r(916) = .00$, $p = .90$. Neighborhood quality (at year five) and physical activity frequency (at year five) had a nonsignificant negative correlation $r(916) = -.05$, $p = .14$.

# of health conditions	Women						Men					
	65-71		72-78		79-85		65-71		72-78		79-85	
	n = 229		*n* = 164		*n* = 78		*n* = 224		*n* = 154		*n* = 69	
	%	*SE*	%	*SE*	%	*SE*	%	*SE*	%	*SE*	%	*SE*
0	22.3	.03	8.7	.02	20.5	.03	28.1	.03	18.2	.03	21.7	.05
1	41.5	.03	31.0	.04	25.6	.03	37.5	.03	40.9	.04	30.4	.06
2	26.2	.03	24.9	.03	37.2	.04	24.6	.03	24.0	.03	34.8	.06
3	7.4	.02	6.6	.02	15.4	.03	7.6	.02	12.9	.03	10.1	.04
4	2.2	.01	0.4	.00	1.2	.01	1.3	.01	2.6	.01	2.9	.02
5	0.0	.00	0.0	.00	0.0	.00	0.9	.01	0.6	.01	0.0	.00

Table 4-2: Comorbidity Prevalence by Age and Gender

Variables	1	2	3	4	5	6	7	8	9
1. Func. Health (W2)	_								
2. Morbidity (W1)	-.17***	_							
3. Age (W1)	-.14***	.10**	_						
4. Physical Act. (W1)	.16***	-.12***	.03	_					
5. Physical Act. (W2)	.30***	-.20***	-.17***	.32***	_				
6. Social Cont. (W1)	.04	-.05	.03	.09**	.08*	_			
7. Social Cont. (W2)	.10**	-.01	-.08*	.09**	.11**	.22***	_		
8. Pain Intensity (W2)	-.04	.09**	-.01	.05	.00	.17***	.72***	_	
9. Neighborhood (W2)	.03	.07*	.00	.05	-.05	-.09**	-.12***	-.05	_
Variables	1	2	3	4	5	6	7	8	9
M	6.49	1.33	72.56	3.57	2.54	3.39	3.14	.80	2.18
SD	1.13	.99	5.35	.94	1.65	3.29	3.36	2.57	0.29
Range	0-7	0-5	65-85	0-4	0-4	0-6	0-6	0-6	1.6-2.9

$*p < .05$. $**p < .01$. $***p < .001$.

Table 4-3: Correlations Between Key Variables of Interest

4.3 Effects of Morbidity Status on Five-Year Functional Health Status

To test hypothesis 1, that functionally independent older adults presenting with multiple health conditions will experience a poorer functional health status at the end of five years compared to those presenting with fewer condition, a simple linear regression was calculated to evaluate the relationship between functional health status (measured on a scale from 0-7) and morbidity status (from 0-5 conditions) as reflected in the NSHAP study scale. Results revealed that baseline morbidity status significantly predicted functional health status $R^2 = .03$, $F(1, 916) = 25.67$, $p < .001$, with each additional health condition translating to a .19-point reduction to functional health score (Table 4-4).

4.4 The Role of Physical Activity

To test hypothesis 2, that the relationship between baseline morbidity status and functional health status (at year five) is partially mediated by physical activity frequency (at year five), a multiple linear regression was calculated to evaluate the relationship between functional health status scores based on morbidity status and physical activity frequency (Table 4-4). As displayed in table 4-4, a significant regression equation was found $R^2 = .10$ $F(2, 915) = 51.16$, $p < .001$. Upon further examination, both morbidity status ($b = -.12$ $t(915) = -3.41$, $p = .001$) and physical activity frequency ($b = .19$ $t(915) = 8.64$, $p < .001$) were statistically significant predictors of functional health status, with each additional health condition reported resulting in a reduction to functional health status scores, while every point-increase in physical activity frequency was associated with a .19-point increase in functional health status scores.

Finally, a full prediction model was constructed that adjusted for covariates. A multiple linear regression was calculated to predict functional health status based on baseline morbidity status and physical activity frequency (Table 4-4). A significant regression equation was found $R^2 = .12$ $F(12, 905) = 9.89$, $p < .001$. Morbidity status ($b = -.12$ $t(905) = -3.15$, $p < .01$) and physical activity frequency ($b = .17$ $t(914) = 7.56$, $p < .001$) remained significant predictors (Table 4-4). In addition, age ($b = -.02$ $t(905) = 2.60$, $p < .01$) emerged as the only socio-demographic characteristics that significantly predicted functional health status. Having multiple health conditions and being older at baseline predicted poorer five-year functional health status, while engaging in frequent and routine physical activity at five-year follow-up was associated with an improved functional health status.

Predictor Variables		**Regression 1**		**Regression 2**		**Regression 3**
		Parameter Estimates (*SE*)				
Morbidity Status		-.19 (.04)***		-.12 (.04)***		-.12 (.04)**
Age						-.02 (.007)***
Gender (referent: Male)						-.03 (.07)
Ethnicity (referent: White)						
Black						-.14 (.10)
Latino						-.18 (.54)
Asian						.34 (.30)
Other						.06 (.23)
Education (referent: < HS)						
HS diploma						.18 (.11)
Some college						.14 (.11)
Bachelor's						.07 (.12)
Household Income						5.33e-07 (4.75e-07)
Physical Activity Frequency				.19 (.02)***		.17 (.02)***
R^2		.03		.10		.12
R^2 *(adjusted)*		.03		.09		.10

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

Table 4-4: Simple and Multiple Linear Regression with Functional Health Status as the Outcome Variable

4.5 Body pain, social engagement, and neighborhood quality as moderators

As a precursor to examining hypothesis 3a-c, a simple linear regression was calculated to predict physical activity frequency (at year five) based on baseline morbidity status (Table 4-5). Morbidity status was a statistically significant predictor of physical activity frequency $R^2 = .04$, $F(1, 916) = 38.93$, $p < .001$. Specifically, each additional health condition reported translated to a .33-point reduction to physical activity frequency five years later.

Next, a multiple linear regression was calculated to predict physical activity frequency (at year five) based on baseline morbidity status, social contact frequency (at year five), body pain intensity (at year five), neighborhood quality (at year five), and covariates (Table 4-5). A significant regression equation was found $R^2 = .11$ $F(14, 871) = 7.96$, $p < .001$. Morbidity status ($b = -.25$) remained a significant predictor ($p < .001$), while social contact frequency ($b = .06$) and body pain intensity ($b = -.06$) also emerged as significantly correlated with physical activity frequency ($p < .05$). However, neighborhood quality was nonsignificant $p > .05$ (Table 4-5).

Lastly, to test hypotheses 3a-c, that the relationship between morbidity status and physical activity frequency would be moderated by social contact frequency, body pain intensity, and neighborhood quality, the full model was considered which included interaction terms while adjusting for covariates (Table 4-5). A significant regression equation was found $R^2 = .12$, $F(17, 868) = 6.89$, $p < .001$. However, none of the interaction terms reached statistical significance with all *p's* > .05.

Predictor Variables		**Regression 1**		**Regression 2**		**Regression 3**
		Parameter Estimates (*SE*)				
Morbidity Status		-.33 (.05) ***		-.25 (.05) ***		-.32 (.04) *
Age				-.05 (.01) ***		-.05 (.01) ***
Gender (referent: Male)				-.27 (.12) *		-.28 (.11) **
Ethnicity (referent: White)						
Black				-.32 (.16) *		-.34 (.16) *
Latino				-.44 (.79)		-.53 (.79)
Asian				.04 (.44)		.05 (.44)
Other				-.43 (.34)		-.48 (.34)
Education (referent: < HS)						
HS diploma				.43 (.16) **		.44 (.16) **
Some college				.39 (.16) *		.39 (.16) **
Bachelor's+				.56 (.18) **		.56 (.18) **
Annual Income				1.17e-06 (7.53e-07)		1.15e-06 (7.52e-07)
Social Contact Frequency				.06 (.02) *		.01 (.04)
Body Pain Intensity				-.06 (.03)		.02 (.05)
Neighborhood Quality				.05 (.19)		-.32 (.32)
Morbidity[x]Social						.04 (.02)
Morbidity[x]Pain						-.05 (.03)
Morbidity[x]Neighborhood						.28 (.18)
R^2		.04		.11		.12
R^2*(adjusted)*		.04		.10		.10

$*p < 0.05$; $**p < 0.01$; $***p < 0.001$.

Table 4-5: Physical Activity Frequency as the Outcome Variable with all Terms Included

4.6 Post-hoc Analyses

Certain health conditions may impact functional health differently, therefore, a post-hoc analysis was conducted to determine if specific conditions more strongly predicted five-year functional health status. A multiple linear regression was calculated based on arthritis, hypertension, diabetes, history of stroke, and history of heart attack (Table 4-5). A significant regression equation was found $R^2 = .03$, $F(5, 912) = 6.42$, $p < .001$. Arthritis ($b = -.32$ $t(912) = -4.36$, $p < .001$) and hypertension ($b = -.16$ $t(912) = -2.07$, $p < .05$) emerged as statistically significant predictors, where a diagnosis of arthritis translates to a reduction to functional health status score that is doubled the reduction posed by a diagnosis of hypertension. All remaining health conditions became nonsignificant (*p's* > .05).

As arthritis and hypertension emerged as significant predictors of functional health scores in previous models, a post-hoc analysis was conducted to examine the relative contribution that these two conditions made to functional health status. Morbidity status was dropped from the model, and a multiple linear regression was calculated to evaluate the relationship between functional health status based on having a diagnosis of arthritis and/ or hypertension, and physical activity frequency (Table 4-5). A significant regression equation was found $R^2 = .11$, $F(3, 914) = 36.48$, $p < .001$. Arthritis ($b = -.29$ $t(914) = -4.02$, $p < .001$) and physical activity frequency ($b = .19$ $t(914) = 8.93$, $p < .001$) emerged as statistically significant predictors of functional health scores. Hypertension became nonsignificant, which suggested a full mediation effect by physical activity frequency.

Arthritis was also inserted into the full model (Table 4-5). A significant regression equation was found $R^2 = .12$, $F(12, 905) = 10.34$, $p < .001$. Arthritis ($b = -.28$ $t(905) = -3.83$, $p < .001$) remained statistically significant while controlling for both physical activity frequency at and covariates. Extending from the previous models, the current model suggests that having arthritis and being older at baseline is associated with a poorer functional health status five years later. Acknowledging the concern that arthritis and age could demonstrate multicollinearity, Variance Inflation Factors (VIF) were computed with all predictors < 2.0, which indicates that multicollinearity was not an issue.

Predictor Variables		Regression 1		Regression 2		Regression 3
		Parameter Estimates (*SE*)				
Morbidity (referent: None)						
Arthritis		-0.32***		-0.28 (.07)***		-.28 (.07) ***
Hypertension		-0.16*		-0.09 (.07)		
Stroke		-0.29		-0.21 (.15)		
Heart Attack		-0.04		-0.01 (.11)		
Diabetes		-0.10		-0.00 (.09)		
Gender (referent: Male)						.00 (.07)
Age						-0.02 (.01) *
Ethnicity (referent: White)						
Black						-.15 (.10)
Latino						-.19 (.54)
Asian						.36 (.30)
Other						.01 (.23)
Education (referent: < HS)						
HS diploma						.19 (.11)
Some college						.15 (.11)
Bachelor's degree+						.08 (.12)
Annual Income						4.69e-07 (4.74e-07)
Physical Activity				.19 (.02) ***		.18 (.02) ***
R^2		0.03		0.11		0.12
R^2(adjusted)		0.03		0.10		0.11

**p* < 0.05; ***p* < 0.01; ****p* < 0.001.*

Table 4-6: Functional Health Status as the Outcome Variable and Morbidity Status separated into Disease Types

CHAPTER 5

DISCUSSION

5.1 Discussion

Existing literature indicates that routine physical activity can help prevent diseases, and improve functioning, with these being benefits to individuals across the life spectrum (Paterson and Warburton, 2010). However, few studies have examined the effect of physical activity on long-term functional health for older adults with preexisting health conditions. This study sought to explore the relationship between certain health conditions and functional health over a five-year period, and the role of physical activity in mediating this relationship. In addition, personal, social, and environmental characteristics were considered as moderating the relationship between baseline morbidity status and physical activity frequency.

Results of the secondary analysis supported hypothesis 1, i.e., that baseline morbidity status predicts functional health status five years later. Furthermore, a post-hoc analysis revealed that having arthritis and hypertension independently predicted functional health status five years later, although both variables have limited explanatory power.

Hypothesis 2 was also supported, with both baseline morbidity status and physical activity frequency (at year five) emerging as statistically significant predictors of functional health status. Including physical activity frequency in the model resulted in morbidity status decreasing from $b = -.19$ to $b = -.12$, which suggests a partial mediation effect by physical activity frequency. A post-hoc analysis revealed that physical activity frequency fully mediated the relationship between hypertension and functional health status, while arthritis remained statistically significant.

Hypothesis 3 was not supported as all interaction terms were nonsignificant. However, both social contact frequency (at year five) and body pain intensity (at year five) were independently related to physical activity frequency (at year five). Neighborhood quality was nonsignificant in all models.

5.2 Comorbidity and Functional Health Outcomes

Hypothesis 1, that baseline morbidity status would predict functional health status at five years was supported. Specifically, findings revealed that reporting multiple health conditions was inversely related to functional health five years later, with each additional diagnosis resulting in a .19-point reduction to functional health scores.

Further analysis revealed that only arthritis and hypertension emerged as statistically significant predictors of functional health status. The relationship between arthritis and functional disability has been well-documented (Boult et al., 1994; Ralph et al., 2013); However, hypertension became nonsignificant once physical activity frequency was adjusted for, which suggests that hypertension does not directly influence functional health outcomes, but does impact other lifestyle behaviors that are more closely associated with functional health. Importantly, arthritis and hypertension were the most prevalent health conditions endorsed by the sample, which may have facilitated detection of an effect above and beyond other conditions (i.e., stroke, heart attack, diabetes mellitus) that were less prevalent in this sample.

Previous research has shown that such conditions as stroke, heart attack and diabetes influence functional health status (Markides et al., 1996; Peek et al., 2003). However, only those respondents who were functionally independent at baseline were included in the study, and therefore, although main effects were not found for the subsample included in this study, main effects of these other conditions on functional health status may exist for the larger NSHAP sample. In other words, it is possible that a larger sample size would have resulted in greater statistical power, and thereby made it easier to detect any effects posed by stroke, heart attack, and diabetes. Interestingly, the five-year rate of functional decline for the subsample went from 7.0 points at baseline to 6.49 points, which underscores the fact that the subsample was quite impervious to functional decline. Although this may be taken as a positive quality of the subsample, from a statistics perspective, the lack of variability in functional health status scores may have further obscured potential effects of specific health conditions on functional health status.

5.3 Mediation Effect of Physical Activity

Hypothesis 2, that physical activity frequency would partially mediate the relationship between morbidity status and functional health status five years later was supported. Results revealed that engaging in routine physical activity was related to a net gain in functional health scores above and beyond the net losses sustained by having multiple health conditions. Therefore, physical activity may be viewed as a protectant against deleterious effects that health conditions pose to functional health outcomes. However, for certain conditions (i.e., arthritis), physical activity does not fully eliminate the threat to functional health, but it may decelerate the rate of functional decline. So, physical activity can be considered a modifiable factor of functional health, and therefore, promoting greater levels of physical activity across the lifespan would benefit both those without health conditions and those reporting multiple health conditions. Further, hypertension was fully mediated by physical activity frequency.

5.4 Social Contact, Body Pain, and Neighborhood Quality

Hypothesis 3a-c, that a) social contact frequency, b) body pain intensity, and c) neighborhood quality would moderate the relationship between baseline morbidity status and physical activity frequency five years later was not supported.

The selection of these variables was informed by previous research that has shown each of these variables to be independently related to physical activity (Verbrugge and Jette, 1994; Stuck et al., 1998; Krol-Zielinksa et al., 2011). The NSHAP datasets enabled for the evaluation of these variables in combination, and exploring their relative contribution to physical activity levels in older adulthood. Secondly, this study examined these variables within the context of the impact morbidity status has on physical activity frequency, which is a unique contribution given that morbidity status has rarely been included in similar investigations of aging, physical activity, and functional health.

Results revealed that neither social contact frequency, perceived body pain, nor neighborhood quality moderate the relationship between morbidity status and physical activity frequency. This trend appeared for both the model that included the additive item (comorbidities) and the model that only included arthritis. Specifically, none of the interaction terms emerged as statistically significant predictors of physical activity frequency. However, both social contact frequency and perceived body pain were found themselves to be independently related to physical activity frequency, with social contact frequency demonstrating a positive relationship with physical activity, while perceived body pain demonstrated an inverse relationship with physical activity frequency.

5.4.1 Clarifying the Role of Social Contact

Consistent with previous studies, the present findings demonstrate that leveraging elements of the social environment may be key to promoting increased levels of physical activity in the older adult population (Mendes de Leon, Gold, Glass, Kaplan, and George, 2001; Mendes de Leon, Glass, and Berkman, 2003). In addition, such approaches may also address the issue of social isolation that many older adults experience. Social isolation in older adulthood has been associated with adverse health consequences including: high blood pressure, stroke, and depression (Cornwell and Waite, 2009). Although social isolation was not explored in this study, it will be useful to further explore its relationship to functional health outcomes.

5.4.2 Clarifying the Role of Body Pain

Perceived body pain also emerged as a key factor contributing to physical activity, but previous studies have yielded mixed findings on this topic (Sitthipornvorakul, Janwantanakul, Purepong, Pensri, and van der Beek, 2011; Gordon and Bloxham, 2016). Specifically, previous findings suggest that older adults who experience intense body pain are less likely to engage in active behaviors to avoid exacerbating their symptoms i.e., disuse (Gordon and Bloxham, 2016). Conversely, a growing body of evidence recommends engaging in physical activity for the purposes of coping with pain symptomology (Taylor, 2014).

The findings from the present study are more typical i.e., as an individual experiences greater levels of body pain, they respond by becoming less active to avoid exacerbating their symptoms. Body pain can be debilitating, and for some, the most effective intervention is pain management through medication; However, such medications may include analgesics, which tend to cause drowsiness. Although this may sound like an innocuous side effect, in the context of older adulthood, with a high fall risk, and fall risk having strong associations with future disability, this creates the potential for a cascade of events that could lead to premature functional disability.

5.4.3 Clarifying the Role of the Physical Environment

Neighborhood quality did not emerge as a moderator of the relationship between health condition status and physical activity, nor was it significantly related to physical activity. Studies exploring the connection between the built environment and physical activity has yielded mixed findings (Giles-Corti and Donovan, 2002; Handy, Boarnet, Ewing, Killingsworth, 2002; Li, Fisher, Brownson, and Bosworth, 2005).

Researchers have found that several elements of the built environment are related to physical activity, including traffic density, mixed land use, and street connectivity (Craig, Brownson, Cragg, Dunn, 2002; Li, Fisher, Brownson, Bosworth, 2005). However, as most studies exploring this topic have been cross-sectional in nature, it has been difficult to overcome confounding factors such as self-selection, i.e., active individuals seeking out living environments that support active lifestyles. During the thesis pilot field study, this trend also emerged. Specifically, many areas in Ithaca can be considered as moderate-to-highly walkable environments, and Ithaca also offers its inhabitants access to natural preserves. Several older adults that were interviewed confirmed that as they transitioned to retirement, they were seeking places that would align with their preference for maintaining an active lifestyle. All interviewees were community-dwelling, functionally independent, and active older adults. For the secondary analysis, the main exclusion criterion was reporting any functional limitations at baseline. Therefore, the findings from the present study may be specific to this cohort, but may not generalize to the larger sample of older adults who participated in the NSHAP study.

To reference the environmental docility hypothesis, individuals who have functional limitations tend to be more strongly impacted by elements of the physical environment (Nehemow and Lawton, 1973). As the present investigation did not include older adults who reported a compromised functional health status, this may, in part, explain the finding that neighborhood quality did not moderate the relationship between baseline morbidity status and physical activity frequency.

Studies that have examined the relationship between disability and the physical environment have shown that for those individuals who have an expressed functional disability, living environments can be designed to accommodate such limitations, which thereby supports them in remaining functionally independent (Mann et al., 1999). In addition, there is no standardized measurement for assessing the walkability of the built environment, and thus, it is difficult to compare findings across studies that applied different metrics to the built environment (Williams, 2007). The present study did not assess walkability. Taken from the NSHAP study methods the quality of the physical environment was distilled along five dimensions i.e., cleanliness, neighborhood density, noise intensity, pollution, traffic density (O'Muircheartaigh, Eckman, and Smith, 2009). This measurement was taken by the interviewer at a single time point, and therefore, changes to the environment that may have occurred over time was not assessed. Furthermore, there is not a theoretical basis describing how the chosen dimensions are thought to influence the performance of active behaviors at the community level.

Some studies have found that environmental aesthetics are associated with walking behavior (Brownson, Baker, Housemann, Brennan, and Bacak, 2001), but this has not been a consistent finding across studies that assessed this dimension (Giles-Corti and Donovan, 2002). In addition, the average neighborhood quality rating for the subsample was 2.2 ($SD = 0.3$), which reflects a high-quality neighborhood. In previous research, aspects of the neighborhood, including aesthetics has been associated with social cohesion, feelings of safety, and social connectedness (Addy, Wilson, Kirtland, Ainsworth, Sharpe, and Kimsey, 2004). However, this too is complicated by the lack of a standardized methods of assessing these constructs (Williams, 2007). Specifically, neighborhood aesthetics has been operationalized in several different ways across studies, and therefore, it is difficult to make comparisons between studies (Williams, 2007). In addition, for the NSHAP study, neighborhood quality assessment was not taken from the perspective of respondents. It is quite possible that individuals who reside in neighborhoods for extended periods may develop more positive appraisals of the neighborhood, or vice versa, which may influence the types of behaviors they perform.

CHAPTER 6

CONCLUSION

6.1 Conclusion

Two main patterns have emerged from this investigation, and are supported by a growing body of literature. Specifically, physical activity appears to be crucial to maintaining functional independence during the latter stages of life, and for older adults, social interaction is one pathway to increasing physical activity frequency. These key factors also emerged during the pilot field interview stage of this thesis project, with community-dwelling older adults describing their motivation to engage in physical activity as being closely aligned with opportunities for socialization.

Older adults are at a greater risk for functional disability compared with the general population. Factors that include chronic health conditions (e.g., heart disease, diabetes), and lifestyle habits (e.g., sedentary behaviors) have been shown to influence the rate of functional decline during the latter stages of life (Gijsen et al., 2001; Paterson and Warburton, 2010). As a result, older adults as a group, consume the most healthcare resources (CDC, 2013), which is reflected by the ever-growing, yet unsustainable healthcare expenditures attributed to this group annually. Furthermore, the older adult population is the fastest growing age demographic in America, and therefore, to better manage rising healthcare costs, initiatives will need to be implemented that improve the overall health of the older adult population.

6.2 Morbidity by Age and Gender

In the present study, the relationships between functional health and five health conditions (i.e., arthritis, hypertension, diabetes mellitus, stroke, heart attack) were evaluated. Hypertension emerged as the most prevalent health condition, with both men and women across age cohorts endorsing rates of hypertension that in some cases exceeded 50%, with women in the 72-78 cohort reporting rates higher than any other group at 65.2%. Previous studies have shown higher rates of hypertension in older men compared with women (Rigaud and Forette, 2001). One possible explanation for the finding from the secondary analysis is that health information was obtained through self-report, and existing literature indicates that older men tend to be less aware of their health conditions compared with older women (Frost, Wraae, Gudex, Nielsen, Brixen, Hagen, and Andersen, 2012). In addition, men underreport health conditions, which may have resulted in estimations that do not accurately reflect actual health status.

The relatively high rate of hypertension among this subsample was unexpected given that on average, older adults reported engaging in physical activity a few times per week, which suggests that the subsample selected for the secondary analysis was much more physically active compared with the broader older adult population as has been reported elsewhere (Troiano et al., 2008). Further, physical activity has been shown to be inversely related to hypertension (Warburton, Nicol, and Bredin, 2006). Therefore, one explanation for the current finding is that information related to physical activity was provided via self-report, and it has been documented that older adults typically overestimate their levels of physical activity compared with results obtained through more objective methods of measuring physical activity levels in this population (Troiano et al., 2008).

Arthritis emerged as the second commonest health condition, affecting 45.3% of the sample at baseline. Consistent with existing literature, older women endorsed higher rates of arthritis compared with their male counterparts (CDC, 2013). Furthermore, arthritis and age were correlated, with the oldest respondents endorsing higher rates of arthritis compared with their younger counterparts. In addition, most respondents (73.9%) reported being diagnosed with between one and two health conditions, while the oldest women were the most likely of any group to endorse having a combined three health conditions (15.4%). This finding is corroborated by previous research that suggests women tend to live longer with diseases and disability compared with their male counterparts (Ferrucci et al., 1996). Few respondents endorsed having four or more health conditions.

6.3 Limitations

Although the NSHAP datasets, used for the secondary analysis, are robust and capture a wide range of information related to older adult health, a limitation is that much of the data used for the secondary analysis, was collected via self-report. Therefore, a threat to construct validity may be related to a mono-method bias. Older adults also tend to have poorer memory recall compared with younger cohorts, which further complicates response accuracy (Chalfonte and Johnson, 1996).

Several constructs evaluated in the secondary analysis were assessed with a single question (e.g., social contact frequency), which suggests that mono-operation bias may have emerged as a threat to construct validity. In addition, morbidity status was assessed via self-report, but there were no inquiries into symptom severity, nor length of time with the health condition. The question posed was, “Has a medical professional ever told you that you have [**condition**]?” (O’Muircheartaigh, Eckman, and Smith, 2009). Several conditions, such as diabetes mellitus, are thought to be reversible, and therefore, researchers of the present study cannot be certain that participants’ responses accurately reflected their current health status (Taylor, 2014).

Furthermore, it has been reasoned that the higher rate of diseases found in older women can partially be attributed to their greater likelihood of seeking out medical care, which in turn, increases the probability of being diagnosed with a health condition (Frost et al., 2012). Similar rates of disease may be found in men, but given that they are less likely to attend routine medical visits, they may be living with a health condition, but unaware of their status. Therefore, based on the NSHAP datasets used for the secondary analysis, it may have been difficult to accurately model the impact of a given health condition on long-term functional health. This issue is further complicated by the fact that for some of the regression models, a frequency count of the health conditions was taken to assess the impact of comorbidity on functional health status. Although this was well-intentioned, the included health conditions are dissimilar, and it is likely that any additive effect of these conditions cannot be made precise through the current methods. To overcome this issue, all health conditions were included in regression models (independent of each other), which revealed that arthritis was the only health condition that was also a statistically significant predictor of functional health over a five-year period. Hypertension also emerged as a statistically significant predictor of functional health, but it became nonsignificant after adjusting for physical activity frequency. Although the other health conditions were nonsignificant predictors of functional health status, such results should be accepted with caution, as these conditions were less prevalent in the subsample.

Given the complicated nature of disease interactions, the researchers of the present study avoid making firm conclusions about how disease combinations influence functional health outcomes. Disease combinations may interact to disrupt the functioning of body structures in ways that have yet to be fully understood by the medical community. In addition, considering that regression analyses yielded relatively low R^2 values, the associated models have weak explanatory power. Physical activity frequency appeared to have the strongest relationship with functional health status, but it is important to note that the assessment of both functional health status and physical activity frequency were taken during Wave 2 of the NSHAP study, and therefore only correlational interpretations can be made about this relationship. Another limitation is that for the secondary analysis, functional health status was based on six dimensions of behavior related to ADLs. Admittedly, this was done to simplify interpretation of the data, however, certain limitations that people endorsed in the NSHAP study (e.g., inability to drive at night), can also greatly impede one's ability to remain living independently. The rationale behind only including six dimensions of behavior in the present study, is that these behaviors are specific to the home setting, and maintaining oneself within the home setting, which was consistent with the study scope. The NSHAP W2 dataset included additional questions related to Instrumental Activities of Daily Living (IADLs) such as purchasing groceries and taking medication, but as these activities were not considered in the NSHAP W1 dataset, for the present study, the researchers were unable to evaluate the changes in these skills over a five-year period.

Although a strength of the NSHAP datasets is that they included a sample that is representative of the national population, a weakness for the secondary analysis is that only a subsample was included, which was based on baseline functional health status, and therefore, this created a more homogeneous group, which thereby makes it difficult to generalize the results to other older adult groups. However, by only including individuals who were functionally independent at baseline, researchers avoided the complications associated with teasing apart how functional disability begets functional disability, and the challenge of making meaningful interpretations of potential interactions between functional disability and morbidity status.

Another limitation of the secondary analysis is that in the NSHAP study, assessments were taken twice at five years apart, with certain measurements only taken at a single time point, or modified from W1 to W2, which may have influenced the subjects' response patterns. In such cases, the researchers of the present study revised certain answer choices to facilitate comparisons across time points, but in doing so, this may have obscured certain information that influenced the study outcome. In addition, the length of time living with a disability could not be determined from the NSHAP data used for the secondary analysis, which is important as it may have had an impact on the observed rate of functional decline.

A clear pattern emerges in the present study, indicating that as individuals age, their frequency of social contact with close others decreases, and they also tend to become less physically active. However, as assessment periods were five years apart, many life events could have transpired over this duration of time that better explain reductions to both social contact and physical activity frequency. The findings provide a high-level overview of how key factors may be associated, but the findings are limited in offering a more granular understanding of how these factors improve and/ or detract from functional health status, which proves to be an obstacle to proposing interventions to increase physical activity in the older adult population with the goal of improving long-term functional health outcomes.

As previously stated, for the secondary analysis, both physical activity frequency and functional health status were assessed at W2, with this research described as cross-sectional in nature. Therefore, based on the results, it may be concluded that older adults who engage in physical activity also have better functional health outcomes. Alternately, it may be concluded that older adults who have better functional health are also more likely to engage in physical activity. Unfortunately, the present investigation was unable to bring clarity to this issue. However, it is relevant to note that a post-hoc analysis was conducted, where baseline physical activity frequency emerged as a statistically significant predictor of functional health status five years later $R^2 = .10$, $p < .001$, which provides assurances that the direction of the relationship is from physical activity frequency impacting functional health outcome. Several studies that have examined the long-term effects of physical activity on a range of health outcomes have arrived at a similar conclusion, and authoritative bodies such as the Center for Disease Control (2013) have also promoted physical activity as conferring several health benefits to this demographic.

6.4 Future Directions

For most older adults, their greatest asset is their health. However, framing physical activity in terms of its health benefits may not be the most effective method of inspiring this group to engage in routine physical activity. Older adulthood is often hampered by social isolation, and developing new approaches to enhance the social environments may help reduce social isolation in the latter stages of life, and promote increased levels of physical activity. Often, the built environments' relationship with physical activity has been framed in terms of walkability, which is certainly an important characteristic of neighborhood design, but perhaps the focus needs to shift to designing environments that create greater opportunities for social interaction and community engagement. Surely, there is some overlap with these two goals, but it appears that for older adults, relationships to close others emerge as a key motivator in life, and therefore, it will be useful to explore environmental designs from the perspective of socialization as being the catalyst to active behaviors. It will also be necessary to expand an understanding of the types of relationships older adults value most, and the various functions these relationships serve during the latter stages of life. In addition, housing initiatives will need to be implemented that make preferential-based locations more affordable for this demographic, who are often at a disadvantage financially as many are no longer working, and living from a finite retirement fund. It will also be useful to consider human behavior more holistically in the designs of neighborhood environments. Currently, emphasis is on walkable environments, but the goals and desires that older adults have while in community environments is often overlooked.

Emerging technology may also have a role to play in addressing the needs of older adults, and therefore, future research will be needed to examine the effects of technology usage on creating opportunities for socialization in older adulthood. Further, research may be needed to explore technology implementation strategies that are acceptable to and consistent with the values of older adults. Commercial interests have skewed younger in targeting audiences for emerging technologies, and often older adults have been excluded from these markets. However, more recently, industries such as healthcare have begun to embrace emerging technology, and older adults will naturally become benefactors of future products that will be brought to market.

Research will also be needed to evaluate the comparative effectiveness of technological solutions that are derived from a disease-management model and those that originate from a model of prevention. Furthermore, to maintain a social role identity, interventions will need to be developed that support older adults in making meaningful contributions at the community level, which may dissuade them from retreating to the confines of their homes to lead a predominantly sedentary lifestyle. Admittedly, technology cannot be taken as the panacea to all the issues faced by this demographic, but in terms of scalability and cost-effectiveness, it may become the most effective method of enacting positive behavioral change in this cohort.

The present investigation was initially propelled by a desire to explore healthcare costs, and how best to reduce costs while helping the greatest number of people. I conclude that exporting healthcare from the hospital or clinic setting and embedding health and wellness into the daily routines of older adults will need to become a fundamental goal, which can be achieved through several pathways. One pathway is through the environmental design (e.g., air and water purification, biophilic design), but one critique of this approach is that it can be cost-prohibitive, and does not scale all too well, with one consequence being inequity of benefit. A second pathway is through technological advances. A common misconception that has persisted for some time is that older adults are resistant to adopting emerging technologies. However, a growing body of research, led by researchers at Georgia Tech (Mitzner, Boron, Fausset, Adams, Charness, Czaja, Dijkstra, Fisk, Rogers, and Sharit, 2010), has explored this issue in depth, which has demonstrated that older adults are willing to embrace technology, but the value that it poses to them needs to be made explicit. Many of the most popular commercial products fail in this regard, often riding a wave of temperamental enthusiasm generated by younger cohorts, which has led to an abundance of digital products and services that do not respond to substantive social issues, and therefore, is of limited value to a broader audience.

More recently, there have been promising events unfolding in this area. Specifically, social robots have been brought to market (e.g., ElliQ, Jibo, Amazon Echo) to coordinate social activities for older adults. Such products may have a significant impact in the lives of community-dwelling older adults who typically live alone, and may not always be inspired to seek out social interaction. As this product category evolves, it will be interesting to assess the response from older adults, and gather their feedback to refine next generation devices. It is also interesting to consider how emerging technologies will augment physical, cognitive, and perceptual abilities in this cohort (e.g., exoskeleton suit, contact lens glucose monitor). There are many reasons to be optimistic about the future, but we must remain steadfast in research and development efforts aimed at the needs of a growing older adult population. Ultimately, the intersection between built environment design, emerging technology, and older adult health is the focal point for the next wave of innovation, and a point that may signal the reversal of disease and disability trends in the older adult population.

BIBLIOGRAPHY

Addy, C.L., Wilson, D.K., Kirtland, K.A., Ainsworth, B.E., Sharpe, P., Kimsey, D. (2004). Associations of perceived social and physical environmental supports with physical activity and walking behavior. *American Journal of Public Health, 94*(3), 440-443.

Avlund, K., Lund, R., Holstein, B.E., Due, P. (2004). Social relations as determinants of onset of disability in aging. *Archives of Gerontology and Geriatrics, 38*, 85-99.

Baltes, P.B., Baltes, M.M. (1990). Psychological perspective on successful aging: The model of selective optimization with compensation. In P.B. Baltes and M.M. Baltes (Eds.), *Successful aging: Perspectives from the behavioral sciences*, 1-34. New York: Cambridge University Press.

Baltes, M.M., Carstensen, L.L. (1996). The process of successful aging. *Ageing and Society, 16,* 397–422.

Bassuk S.S., Glass T.A., Berkman L.F. (1999). Social disengagement and incident cognitive decline in community-dwelling elderly persons. *Annals of Internal Medicine, 131,* 165–73.

Berkman, L.F., Glass, T., Brissette, I., Seeman, T.E. (2000). From social integration to health: Durkheim in the new millenium. *Social Science & Medicine, 51,* 843-85.

Boult, C., Kane, R. L., Louis, T. A., Bouldt, L., McCaffrey, D. (1994). Chronic conditions that lead to functional limitation in the elderly. *Journal of Gerontology: Medical Sciences, 49A*, M28–M36.

Bisschop, M.I., Kriegsman, D.M.W., van Tilburg, T.G., Penninx, W.J.H., van Eijk, K.T., Deeg, D.J.H. (2003). The influence of differing social ties on decline in physical functioning among older people with and without chronic diseases: The Longitudinal Aging Study Amsterdam. *Aging Clinical and Experimental Research, 15,* 164-173.

Brownson, R.C., Baker, E.A., Housemann, R.A., Brennan, L.K., Bacak, S.J. (2001). Environmental and policy determinants of physical activity in the United States. *American Journal of Public Health, 91*(12), 1995-2003.

Carp, F. M. (1988). Significance of mobility for the well-being of the elderly. *Transportation Research Board, 218*(2). Washington, D.C.

Carr, K., Weir, P.L., Azar, D., Azar, N.R. (2013). Universal design: A step toward successful aging. *Journal of Aging Research.* 1-8.

Center for Disease Control and Prevention. (2013). The state of aging and health in America 2013.

Centers for Disease Control and Prevention, US Dept. of Health and Human Services. Atlanta, GA.

Chalfonte, B.L., Johnson, M.K. (1996). Feature memory and binding in young and older adults. *Memory and Cognition, 24*(4), 403-416.

Clarke, P., Ailshire, J.A., Bader, M., Morenoff, J.D., House, J.S. (2008). Mobility disability and the urban built environment. *American Journal of Epidemiology*, *168*(5), 506-513.

Clarke, P., Nieuwenhuijsen, E.R. (2009). Environments for healthy ageing: A critical review. *Maturitas, 64*, 14-19.

Cornwell, E.Y., Cagney, K.A. (2014). Assessment of neighborhood context in a nationally representative study. *The Journal of Gerontology Series B: Psychological Sciences and Social Sciences.*

Cornwell, E.Y., Waite, L.J. (2009). Social disconnectedness, perceived isolation, and health among older adults. *Journal of Health and Social Behavior*, *50*(1), 31-48.

Craig, C.L., Brownson, R.C., Cragg, S.E., Dunn, A.L. (2002). Exploring the effect of the environment on physical activity: a study examing walking to work. *American Journal of Preventive Medicine, 23*(2 Suppl), 36-43.

Cress, M.E., Buchner, D.M., Questad, K.A., Esselman, P.C., deLateur, B.J., Schwartz, R.S. (1999). Exercise: Effects on physical functional performance in independent older adults. *Journal of Gerontology, 54A*(5), M242-M248.

Cubbin, C., Egerter, S., Braveman, P., Pedregon, V. (2008). Where we live matters for our health: Neighborhoods and health. *Robert Wood Johnson Foundation*, Princeton, New Jersey.

Cunningham, G.O., & Michael, Y.L. (2004). Concepts guiding the study of the impact of the built environment on physical activity for older adults: A review of the literature. *American Journal of Health Promotion, 18*(6), 435–443.

Ferrucci, L., Guralnik, J.M., Simonsick, E., Salive, M.E., Corti, C., Langlois, J. (1996). Progressive versus catastrophic disability: A longitudinal view of the disablement process. *Journals of Gerontology: Medical Sciences*, *51A*, M123-M130.

Fisk, A.D., Rogers, W.A., Kelly, A.J., Fausset, C.B. (2011). Challenges to aging in place: Understanding home maintenance difficulties. *Journal of Housing for the Elderly, 25*(2), 125-141.

Fougeyrollas, P.; Beauregard, L. (2001). Disability: An interactive person-environment social creation. *In Handbook of Disability Studies*; Albrecht, G.L., Seelman, K.D., Bury, M., Eds.; Sage: London, U.K., 171–194.

Fried L, Guralnik J. (1997). Disability in older adults: evidence regarding significance, etiology, and risk. *Journal of the American Geriatrics Society, 45*, 92–100.

Fried L.P., Herdman S.J., Kuhn K.E., Rubin, G., Turano, K. (1991). Preclinical disability: hypotheses about the bottom of the iceberg. *Journal of Aging and Health, 3,* 285-300.

Frost, M., Wraae, K., Gudex, C., Nielsen, T., Brixen, K., Hagen, C., Andersen, M. (2012). Chronic diseases in elderly men: underreporting and underdiagnosis. *Age Ageing, 41*(2), 177-183.

Gijsen, R., Hoeymans, N., Schellevis, F.G., Ruwaard, D., Satariano, W.A., van den Bos, G.A.M. (2001). Causes and consequences of comorbidity: A review. *Journal of Clinical Epidemiology. 54*, 661-674.

Giles-Corti, B., Donovan, R.J. (2002). The relative influence of individual, social and physical environment determinants of physical activity. *Social Science and Medicine, 54*(12), 1793-1812.

Gill, T.M., Williams, C.S., Richardson, E.D., Tinetti, M.E. (1996). Impairments in physical performance and cognitive status as predisposing factors for functional dependence among nondisabled older persons. *Journal of Gerontology: Medical Sciences, 51A*(6), M283-M288.

Gitlin, L.N., Mann, W., Tomit, M., Marcus, S.M. (2001). Factors associated with home environmental problems among community-living older people. *Disability and Rehabilitation, 23*(17). 777-787.

Glass, T.A., Mendes de Leon, C., Seeman, T.E., Berkman, L.F. (1997). Beyond single indicators of social networks: a LISREL analysis of social ties among the elderly. *Social Science and Medicine, 44*(10),1503–1517.

Goethe, N.P., Fanning, J., Awick, E., Chung, D., Wojcicki, T.R., Olson, E.A., Mullen, S.P., Voss, M., Erickson, K.I., Kramer, A.F., McAuley, E. (2014). *Journal of American Geriatric Society, 62*(2), 285-290.

Gordon, R., Bloxham, S. (2016). A systematic review of the effects of exercise and physical activity on non-specific chronic low back pain. *Healthcare* (Basel) 4.

Hallal, P.C., Andersen, L.B., Bull, F., Guthold, R., Haskell, W., Ekelund, U. (2012). Global physical activity levels: Surveillance progress, pitfalls, and prospects. *The Lancet, 380*, 247-257.

Handy, S.L., Boarnet, M.G., Ewing, R., Killingsworth, R.E. (2002). How the built environment affects physical activity. Views from urban planning. *American Journal of Preventive Medicine, 23*(2 Suppl. 1), 64-73.

Haselwandter, E.M., Corcoran, M.P., Folta, S.C., Hyatt, R., Fenton, M., Nelson, M.E. (2015). The built environment, physical activity, and aging in the United States: A state of the science review. *Journal of Aging and Physical Activity, 23,* 323-329.

Huisingh-Scheetz, M., Kocherginsky, M., Schumm, P.L., Engelman, M., McClintock, M.K., Dale, W., Magett, E., Rush, P., Waite, L. (2014). Geriatric syndromes and functional status in NSHAP: rationale, measurement, and preliminary findings. *Journal of Gerontology Series B, Psychological Sciences and Sociological Sciences, 69*(Suppl. 2), s177-90.

Janssen, I., Heymsfield, S.B., Ross, R. (2002). Low relative skeletal muscle mass (sarcopenia) in older persons is associated with functional impairment and physical disability. *Journal of American Geriatric Society, 50,* 889–896.

James, B.D., Boyle, P.A., Buchman, A.S., Bennett, D.A. (2011). Relation of late-life social activity with incident disability among community-dwelling older adults. *The Journal of Gerontology. Series A, Biological Sciences and Medical Sciences,* 1-7.

Karlamangla, A.S., Singer, B.H., McEwen, B.S., Rowe, J.W., Seeman, T.E. (2002). Allostatic load as a predictor of functional decline MacArthur studies of successful aging. *Journal of Clinical Epidemiology, 55,* 696-710.

Kriegsman, D.M.W., Penninx, B.W.J.H., van Eijk, J.T.M., Boeke, A.J.P., Deeg, D.J.H. (1996). Self-reported and general practitioner information on the presence of chronic diseases in community dwelling elderly. *Journal of Clinical Epidemiology, 49*(12), 1407-1417.

Krol-Zielinska, M., Kusy, K., Zielinski, J., Osinski, W. (2011). Physical activity and functional fitness in institutionalized vs. independently living elderly: A comparison of 70-80-year-old city-dwellers. *Archives of Gerontology and Geriatrics, 53,* e10-e16.

Lang, F.R., Rieckmann, N., Baltes, M.M. (2002). Adapting to aging losses: Do resources facilitate strategies of selection, compensation, and optimization in everyday functioning? *Journal of Gerontology: Psychological Sciences, 57B*(6), P501-P509.

Lau, K.M., Parikh, M., Harvey, D.J., Huang, C.J., Farias, S.T. (2015). Early cognitively based functional limitations predict loss of independence in instrumental activities of daily living in older adults. *Journal of the International Neuropsychological Society. 21,* 688-698.

Lawrence, R. H., Jette, A. M. (1996). Disentangling the disablement process. *Journal of Gerontology: Social Sciences, 51B,* S173–S182.

Lawton, M.P., Simon, B. (1968). The ecology of social relationships in housing for the elderly. *The Gerontologist, 8,* 108-115.

Li, F., Fisher, K.J., Brownson, R.C., Bosworth, M. (2005). Multilevel modelling of built environment characteristics related to neighbourhood walking activity in older adults. *Journal of Epidemiology and Community Health, 59*(7), 558-564.

Lipman, B., Lubell, J., Salomon, E. (2012). Housing an Aging Population: Are We Prepared? Available online: http://www.nhc.org/media/files/AgingReport2012.pdf

Markides, K.S., Stroup-Benham, C.A., Goodwin, J.S., Perkowski, L.C., Lichtenstein, M., Ray, L.A. (1996). The effect of medical conditions on the functional limitations of Mexican-American elderly. *Annals of Epidemiology, 6*(5), 386-391.

Mann, W.C., Ottenbacher, K.J., Fraas, L., Tomita, M., Granger, C.V. (1999). Effectiveness of assistive technology and environmental interventions in maintaining independence and reducing home care costs for frail elderly. *Archives of Family Medicine, 8*, 210-217.

Mendes de Leon, C., Glass, T.A., Berkman, L.F. (2003). Social engagement and disability in a community population of older adults. The New Haven EPESE. *American Journal of Epidemiology, 157*(7), 633-642.

Mendes de Leon, C.F., Glass, T.A., Beckett, L.A., Seeman, T.E., Evans, D.A., Berkman, L.F. (1999). Social networks and disability transitions across eight intervals of yearly data in the New Haven EPESE. *Journal of Gerontology: Social Sciences, 54B*(3), S162-S172.

Mendes de Leon, C.F., Gold, D.T., Glass, T.A., Kaplan, L., George, L.K. (2001). Disability as a function of social networks and support in elderly African Americans and Whites: The Duke EPESE 1986-1992. *Journal of Gerontology: Social Sciences, 56B(3), S179-S190.*

Mitzner, T.L., Boron, J.B., Fausset, C.B., Adams, A.E., Charness, N., Czaja, S.J., Dijkstra, K., Fisk, A.D., Rogers, W.A. (2010). Older adults talk technology: technology usage and attitudes. *Computers in Human Behavior, 26*(6), 1710-1721.

Murphy, R.A., Ip, E.H., Zhang, Q., Boudreau, R.M., Cawthon, P.M., Newman, A.B., Tylavsky, F.A., Visser, M., Goodpaster, B.H., Harris, T.B. (2013). Transition to sarcopenia and determinants of transitions in older adults: A population-based study. *The Journal of Gerontology. Series A, Biological Sciences and Medical Science, 69*(6), 751-758.

Mullen, S.P., McAuley, E., Satariano, W.A., Kealey, M., Prohaska, T.R. (2012). Physical activity and functional limitations in older adults: The influence of self-efficacy and functional performance. *The Journal of Gerontology, Series B: Psychological Sciences and Social Sciences, 67*(3), *354-361.*

Nagi, S. (1965). Some conceptual issues in disability and rehabilitation. *In: Sussman M, editor. Sociology and Rehabilitation. Washington, D.C.: American Sociological Association*, 100-113.

Nahemow, L., Lawton, P. (1976). Toward an ecological theory of adaptation and aging.

O'Muircheartaigh, C., Eckman, S., S., Smith. (2009). Statistical design and estimation for the National Social Life, Health, and Aging Project. *The Journal of Gerontology Series B: Psychological Sciences and Social Sciences, 64B*, i12-i19.

Paterson, D., Govindasamy, D., Vidmar, M., Cunningham, D., Koval, J. (2004). Longitudinal study of determinants of dependence in an elderly population. *Journal of American Geriatric Society, 52*, 1632-1638.

Paterson, D.H., Warburton, D.E.R. (2010). Physical activity and functional limitations in older adults: a systematic review related to Canada's Physical Activity Guidelines. *International Journal of Behavioral Nutrition and Physical Activity, 7*(38), 1-22.

Peek, M.K., Ottenbacher, K.J., Markides, K.S., Ostir, G.V. (2003). Examining the disablement process among older Mexican American adults. *Social Science & Medicine, 57*, 413-425.

Philibert, M., Pampalon, R., Daniel, M. (2015). Conceptual and operational considerations in identifying socioenvironmental factors associated with disability among community-dwelling adults. *International Journal of Environmental Research and Public Health, 12*, 3814-3834.

Ralph, N.L., Mielenz, T.J., Parton, H., Flatley, A.M., Thorpe, L. (2013). Multiple chronic conditions and limitations in activities of daily living in a community-based sample of older adults in New York City, 2009. *Preventing Chronic Disease.*

Rigaud, A.S., Forette, B. (2001). Hypertension in older adults. *The Journal of Gerontology. Series A, Biological Sciences and Medical Sciences, 56*(4), M217-M225.

Rochat, S., Cumming, R.G., Blyth, F., Creasey, H., Handelsman, D., Le Couteur, D.G., Naganathan, V., Sambrook, P.N., Seibel, M.J., Waite, L. (2010). Frailty and use of health and community services by community-dwelling older men: the concord health and ageing in men project. *Age Ageing, 1*, 1-6.

Rowe, J.W., Kahn, R.L. (1997). Successful Aging. *The Gerontologist, 37*(4), 433-440.

Santos, D.A., Silva, A.M., Baptista, F., Santos, R., Vale, S., Mota, J., Sardinha, L.B. (2012). Sedentary behavior and physical activity are independently related to functional fitness in older adults. *Experimental Gerontology, 47,* 908-912.

Sattelmair, J.R., Pertman, J.H., Forman, D.E. (2009). Effects of physical activity cardiovascular and noncardiovascular outcomes in older adults. *Clinics in Geriatric Medicine, 25*(4), 677–702.

Sayer A.A., Syddall H., Martin H., Patel H., Baylis D., Cooper C. (2008). The developmental origins of sarcopenia. *Journal of Nutritional Health and Aging, 12,* 427–432.

Seeman, T.E., Bruce, M.L., McAvay, G.J. (1996). Social network characteristics and onset of ADL disability: MacArthur studies of successful aging. *Journal of Gerontology: Social Sciences, 51B*(4), 5191-5200.

Sitthipornvorakul, E., Janwantanakul, P., Purepong, N., Pensri, P., van der Beek, A.J. (2011). The association between physical activity and neck and low back pain: a systematic review. *European Spine Journal, 20*(5), 677-689.

Spector W.D., Fleishman J.A. (1998). Combining activities of daily living with instrumental activities of daily living to measure functional disability. *The Journal of Gerontology: Series B, Psychological Sciences and Social Sciences, 53*, S46–57.

Strawbridge W.J., Cohen R.D., Shema S.J., Kaplan G.A. (1996). Successful aging: predictors and associated activities. *American Journal of Epidemiology, 144*, 135-41.

Stel, V.S., Smit, J.H., Pluijm, S.M.F., Lips, P. (2004). Consequences of falling in older men and women and risk factors for health service use and functional decline. *Age and Ageing, 33*(1), 58-65.

Struck, A.E., Walthert, J.M., Nikolaus, T., Bula, C.J., Hohmann, C., Beck, J.C. (1998). Risk factors for functional status decline in community-living elderly people: a systematic literature review. *Social Science & Medicine, 48,* 445-469.

Stewart, A.L. (2003). Conceptual challenges in linking physical activity and disability research. *American Journal of Preventive Medicine, 25*(Suppl.), 137-140.

Suomi, S. (1997). Early determinants of behaviour: evidence from primate studies. *British Medical Bulletin, 53*, 170-184.

Taylor, D. (2014). Physical activity is medicine for older adults. *Postgraduate Medical Journal, 90,* 26-32.

Troiano, R.P., Berrigan, D., Dodd, K.W., Masse, L.C., Tilert, T., & McDowell, M. (2008). Physical activity in the United States measured by accelerometer. *Medicine and Science in Sports and Exercise, 40*(1), 181–188.

Unger, J.B., Johnson, A., Marks, G. (1997). Functional decline in the elderly: Evidence for direct and stress-buffering protective effects of social interactions and physical activity. *Annals of Behavioral Medicine, 19*(2), 152-160.

Verbrugge, L.M., Jette, A.M. (1994). The disablement process. *Social Science & Medicine. 38*(1), 1-14.

Verbrugge, L.M., Reoma, J.M., Gruber-Baldini, A.L. (1994). Short-term dynamics of disability and well-being. *Journal of Health and Social Behavior, 35*(2): 97-117.

Vermeulen, J., Neyens, J.C.L., van Rossum, E., Spreeuwenberg, M.D., de Witte, L.P. (2011). Predicting ADL disability in community-dwelling elderly people using physical frailty indicators: a systematic review. *BMC Geriatrics, 11*(33), 1-11.

Vincent, G.K., & Velkoff, V.A. (2010). The Next Four Decades: The Older Population in the United States: 2010-2050. *Washington, D.C.: Current Population Reports*.

Visser, M., Simonsick, E.M., Colbert, L.H., Brach, J., Rubin, S.M., Kritchevsky, S.B., Newman, A.B., Harris, T.B. (2005). Type and intensity of activity and risk of mobility limitation: the mediating role of muscle parameters. *Journal of American Geriatric Society, 53*(5), 762-770.

Wahl, H.W., Iwarsson, S., Oswald, F. (2012). Aging well and the environment: Toward an integrative model and research agenda for the future. *The Gerontologist*.

Warburton, D.E., Nicol, C.W., Bredin, S.S. (2006). Health benefits of physical activity: the evidence. *Canadian Medical Association Journal, 23*(2 Suppl), 36-43.

Wiles, J.L., Leibing, A., Guberman, N., Reeve, J., Allen, R.E.S. (2011). *The Gerontologist.*

Williams, C.H. (2007). The built environment and physical activity: what is the relationship? *Robert Wood Johnson Foundation*, Princeton, New Jersey.

World Health Organization. (1980). International classification of impairments disabilities and handicaps. *Geneva: World Health Organization*, 143.

World Health Organization and the World Bank. World Report on Disability. (2011). *WHO Press: Geneva, Switzerland*.

Zunzunegui, M.V., Rodriguez-Laso, A., Otero, A., Pluijm, S.M.F., Blumstein, T., Jylha, M., Minicuci, N., Deeg, D.J.H. (2005). Disability and social ties: comparative findings of the CLESA study. *European Journal of Ageing, 2*, 40-47